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GROUND WATER: WELL DRILLING AND WATER LIFTING EQUIPMENT

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GROUND WATER
WELL DRILLING AND WATER LIFTING EQUIPMENT

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INTRODUCTION:

1. In most countries ground water supplies have been developed to some extent but there are still areas where only extremely shallow wells have been constructed and little or no real ground water abstraction has taken place.

2. These countries are generally those in which the harder rocks predominate, but even in areas of sedimentary deposits modern well drilling techniques have not always been used to the fullest extent and it is the smaller villages and rural communities which have not benefited from the relatively cheap methods of ground water development which are available.

3. Drilling carried out on the smallest scale, utilising only one or two rigs, can be of material benefit and the results obtained, though not spectacular, can be of considerable help in raising the standard of living.

4. In this paper a brief description is given of the plant available for the development of rural and small town water supplies and the types of pumping plant commonly used.

GEOLOGY AND HYDROGEOLOGY:

5. The geological and hydrogeological conditions obtaining in a country are matters which require the first consideration when planning any ground water development scheme, however modest.

6. The nature of the rock to be penetrated will determine to some extent the type of equipment to be utilised and the form of well to be constructed.

7. The depth to water will also have to be considered and the quantity of water likely to be obtained from the particular aquifer being developed.

8. The quality of water to be obtained will determine the constructional materials for use in the borehole. If the water or soil is corrosive special equipment will be required for the lining and screen and must be provided for. The possibility of saline water being met with at lower levels will also affect the depth of the borehole and must be taken into consideration.

9. The following table indicates the range of yield which may be expected from 6" to 8" diameter borings sunk in the type of formation frequently met with in less developed areas.

"TABLE 1"

Geological Formations	Dia. of borehole	Average Range of Depth	Average range of yield in G.P.H.
Weathered granite	6"/8"	100 ft./300 ft	100 to 6,000
Weathered gneiss	6"/8"	50 ft./150 ft	100 to 3,000
Quartzite & quartzitic Sandstone	6"/8"	100 ft./600 ft	100 to 1,200
Shales & tillite	6"/8"	under 100 ft	up to 1,600
Dolomite (Transvall System)	6"/8"	75 ft./100 ft	800 to 1,200
Limestone	6"/8"	150 ft./500 ft	1,000 to 7,000
Sandstones	6"/8"	200 ft./900 ft	3,000 to 12,000
Alluvial & recent sand deposits	6"/8"	200 ft./350 ft	5,000 to 20,000

METHODS OF WATER WELL DRILLING:

10. Water well drilling is carried out by either the percussion or the rotary systems of boring and occasionally by a combination of both methods.

11. As their names imply, in the percussion system penetration is obtained by breaking up the formation by the percussive action of a chisel or bit, the debris being recovered by a bailer, and in the rotary, the formation is broken by the rotational action of a rock roller, or drag bit and the cuttings removed by the circulation of specially prepared mud, or in certain cases by water alone.

PERCUSSION DRILLING:

12. Percussion drilling may be carried out with rod or cable tools and portable trailer or truck mounted cable rigs; with sheerlegs and friction winch, or when drilling is required in soft clays and sands with hand plant utilising a bailer only, and sinking the casing with kentledge.

13. Rod drilling is gradually being superseded by cable drilling except for the construction of large diameter boreholes which are outside the scope of this paper.

14. Trailer mounted rigs are the most commonly used type of water well equipment. Their cost will depend upon the size and depth of bore to be drilled but for rural water well development a rig to drill a 6"/10" diameter borehole to 500 feet would be satisfactory and would cost between £3,000 and £4,000.

15. A set of drilling tools, wire lines and fishing tools for use with the rig would cost a further £2,000.

16. Sheer legs and a friction winch, easily transportable to areas of restricted access cost only some £1,000 per set.

17. The cheapest of all types of percussion equipment which can be used for sinking wells in sands and soft clays, as in India, Pakistan and Egypt, consist merely of a set of sheerlegs of wood or tubular construction, casing of the required diameter, rope or wire line and a bailer for bringing up the sand and clays from inside the casing as it is sunk by the weight of kentledge or sandbags.

18. The use of hand equipment of this latter type while slow in construction is extremely cheap.

19. A power operated grab is also used occasionally for the construction of large diameter shallow bores but is a type of drilling not in common use and is only applicable for working in soft rock formations.

ROTARY DRILLING:

20. Rotary drilling may be conveniently divided into the following basic types.

(a) Mud flush rotary
(b) Water flush rotary
(c) Reverse circulation rotary
(d) Shot rotary

21. Trailer or truck mounted mud flush rotary rigs of a light type are suitable for rural water development but they are more expensive to run than percussion rigs and are generally only used for the construction of boreholes over 300 feet in depth in unconsolidated strata. A rig to drill to 1,000 feet would cost between £11,000 and £12,000. The cost of supplying water and mud can in certain areas be heavy.

22. Water flush rotary equipment consisting of a derrick, drill rod, usually steam quality pipe, flush jointed casing and a centrifugal pump is an inexpensive outfit for use in drilling in sands and clays where a source of water supply for drilling purposes is readily available. The bit used is usually a drag bit or fishtail type and the rods are turned by hand.

23. The whole equipment for sinking 6" bores to 300 feet costs approximately £2,000 and is very suitable for drilling in areas such as lower Bengal, East Pakistan, the Nile Delta and areas of similar geological formation where surface water can readily be obtained for drilling purposes.

24. Smaller outfits for jetting 4" casing can be supplied even more cheaply and this method is particularly successful where water is found in sands at shallow depths and only small diameter boreholes are required, water being within suction lift.

25. The reverse circulation method of drilling in which, as its name implies, the drilling fluid, in this case water, is drawn up the drill pipe and the make up water, which must maintain the borehole full to surface level, is fed directly into the borehole, is not particularly suited to rural development, unless in connection with irrigation.

26. For irrigation wells however to be constructed in sands and clays it is probably the most effective method of drilling which has yet been developed.

27. Reverse circulation drilling requires large quantities of make up water and is particularly suitable therefore where a major drilling programme is to be carried out, so that if necessary water can be pumped from one site to the next.

28. Shot rotary is virtually only used at the present time where large diameter boreholes are to be sunk in sandstones, quarzites and crystalline limestone formations. It has the merit that cores are obtained for geological classification, and the equipment is inexpensive compared to the equivalent size of mud flush rotary plant.

29. In Morocco a number of wells have recently been drilled using air in place of the conventional mud or water as a flushing medium and successful results were obtained.

30. Air is not yet in general use however for water well drilling as it cannot support unstable strata and difficulties are encountered in dealing with water inflows.

31. A further application of the use of air is with the Down-the-hole hammer drills.. A pneumatically operated percussion rock drill is attached to the bottom of the drill pipe and rotated slowly during drilling. Rapid progress can be made in hard rocks but the system is unsuitable for soft rocks.

COMBINATION RIGS:

32. Because of the special advantages of the use of percussion in one forma-

tion and rotary in another, combination rigs which incorporate the equipment for both methods have been designed. With such rigs a rapid change may be made from one method of drilling to another. Combination rigs are not however widely in use.

SELECTION OF DRILLING EQUIPMENT:

33. The selection of drilling equipment for use in any individual area will depend upon the topography, geology, rate of drilling required, quantity of water available for drilling purposes and availability of skilled personnel; the diameter and depth required will also have to be taken into consideration.

34. The depth of the bore will be determined by the hydrogeological conditions obtaining at the site, and the diameter by the yield expected or required and the type of pump to be inserted.

35. Percussion drilling is applicable to all types of formations but is slow in unstable materials such as dune sands, quicksands, and soft clays as casing has to be used to prevent caving.

36. With rotary equipment rapid drilling is possible in most formations. The use of mud enables unstable strata to be handled satisfactorily and rapidly but for shallow wells percussion equipment may be preferred.

37. In cavernous and extremely permeable lost circulation zones rotary tools are unsatisfactory owing to the difficulty of maintaining a return flow.

38. Alluvial formations consisting of boulders, cobbles and coarse gravels are difficult to drill with any equipment but the cable tool percussion method is the most suitable.

39. Metamorphic and igneous rocks can be handled by both methods of drilling but for shallow depths in undeveloped countries the percussion method is likely to give the best overall results.

40. The following table may be used as a guide to the choice of drilling equipment.

"TABLE 2"

Drilling method	Usual dia. range	Depth range	Optimum rock type	Drilling water requirements per 8 hr shift
				gallons
Hand percussion (sludger method)	6"/15"	50/400 ft	Sands & soft clays	100/150
Rod percussion	6"/24"	50/200 ft	All formations except hard rock	100/150
Cable percussion	6"/21"	50/500 ft	All stable formations	100/150
Mud flush rotary	4"/18"	300/1500 ft	All formations except boulders chert and cavernous limestone	750/15000
Water flush rotary	6"/8"	50/500 ft	Sands and soft clays	10000/50000
Water flush jetting	4"/6"	50/100 ft	Sands and soft clays	500/1000
Reverse circulation	15"/60"	100/450 ft	Sands, gravels and soft clays	30000/50000
Shot rotary	6"/36"	50/500 ft	Igneous rocks, sandstones & crystalline limestones	4000/8000

DRILLING RATES:

41. Drilling rates as such are of little real value as so many factors can affect them. The following footage rates and overall monthly average based on a number of months working however may be of use in planning a drilling programme.

"TABLE 3"

Formation	Av. footage per month in completed boreholes.	Drilling Method
Sand and Gravel	309 ft.	Percussion
Weathered granites and schists	123 ft.	Percussion
Sandstones	316 ft.	Mud Rotary
Sandstones and shales	1,100 ft. x	Mud Rotary
Limestone	398 ft.	Percussion
Clay, shale and sand	319 ft.	Mud Rotary
Clay, shale and sand	210 ft.	Percussion
	x 3 shift working	

42. The rates given in table 3 include moving between sites and insertion of casing and screens where applicable.

43. Costs of drilling will, depend upon the strata to be drilled, the area in which the work is to be carried out and the number, diameter, depth and spacing of the bores.

44. Costs generally will range between £3 and £10 per foot.

BOREHOLE CASING:

45. All boreholes require lining if only for the upper 20 feet to 50 feet as a means of protection against immediate pollution, and where possible should be grouted externally.

46. If the strata to be supported and water obtained are not corrosive steel well casing to A.P.I. or a water well standard should be used.

47. Where corrosion is likely, cast iron or semi steel lining may be used if available locally. Alternatively plastic pipes may be used for small diameters, asbestos cement up to 11 inch internal diameter and glass fibre reinforced polyester casings for diameters up to 24 inch. Wood and compressed bakelized wood may also be used in sizes up to approximately 23 inch internal diameter. If greater strength is required for deep wells steel pipes plastic coated will be found to be satisfactory.

SAND SCREENS:

48. In unconsolidated strata some form of slotted pipe or screen is required with or without gravel packing.

49. A vast variety of screen is available and the choice will largely be a matter of personal opinion.

50. Screens should be inserted with a sand trap at the base and designed so that the entry velocity of the water is as low as possible.

51. Prepacked screens in which a fine gravel is bonded to a plastic coated steel screen have proved effective but care is required in handling them.

52. Where a mobile gravel pack is used the gravel should be clean, well rounded and carefully graded in relation to the sand to be retained.

DEVELOPMENT OF BOREHOLES:

53. The yield of almost all boreholes can be improved on completion by the adoption of one or more of the following development techniques:

(a) Swabbing
(b) Backblowing
(c) Acid treatment
(d) Calgon treatment
(e) Pressure fracturing
(f) Shot firing

54. Swabbing or surging (with a surge plunger) is one of the most effective and cheapest methods of developing boreholes in all types of formation. The swab or plunger is operated up and down a borehole under about 15 foot of water for a period determined by the driller. The swab is then withdrawn and the hole cleaned out and the process repeated until no further sand or cuttings are brought into the borehole. Increases in yield of up to 1,000% have been obtained.

55. Backblowing requires the use of a compressor to force the water back into the fissures or through the screen. By building up a pressure and suddenly releasing it an effective washing action is obtained. Increase in yield with this method of development range from 30% to 50%.

56. In limestones and chalks very considerable increases in yield can be obtained by treating boreholes with acid. The quantity of acid will range from 3 to 40 tons and increases in yield of up to 700% may be expected.

57. Calgon is used primarily to disperse drilling mud but also to increase the yields of old wells which have fallen off, due to plugging with minerals deposited by the water, or with clay and silt. Increases of yield of up to 300% have been recorded.

58. Pressure fracturing, an oil field technique, has been successfully used in South Africa to obtain increased supplies of ground water from low permeability rocks. The fracturing is achieved by pumping or tamping a viscous fluid sand suspension into the borehole. Increases in yield of 300-400% have been obtained with in one recorded case an increase of 1,100%.

59. The yield of boreholes sunk in sand rocks may often be increased by shattering the rock through the explosive force of small charges of gelignite. Directional charges may also be used in certain circumstances where it is necessary to perforate casing in situ. Increases in yield of 200-300% have been obtained but diminution in yield can also occur by stemming clayey or marley material into fissures.

PUMPING PLANT:

60. Pumping plant for small scale ground water supplies must be simple to operate and in respect of hand plant must be as robust as is commensurate with an economic price.

61. For small village supplies hand pumps are adequate. The semi rotary type being suitable for use where water is within suction lift, and the deep well type where water levels are lower.

62. A pump which has proved suitable for village supplies is one fitted with a heavy flywheel with detachable handle and bolted on balance weight. Yields of 70 gallons per hour can be pumped from a depth of 200 ft. below surface and yields of 300 gallons per hour from 50 feet.

63. For larger supplies where a distribution system and overhead tank is to be provided power pumps have to be installed.

64. The simplest type is the beam operated deep well reciprocating pump driven by belt from an oil engine. Alternative types of pump head are the totally enclosed oil bath type.

65. For supplies of over 3,000 gallons per hour submersible and turbine pumps are the most suitable to install.

66. To operate submersible pumps an alternating current electric supply has to be made available but turbine pumps may be driven from oil engines if required through gear heads.

67. The jet pump has also proved satisfactory for pumping small supplies of water from boreholes in rural areas.

68. Comparative capacities of borehole pumps are as follows:-

"TABLE 4"

Type of Pump	Deep Well Plunger	Submersible	Turbine	Jet
Dia. of Bore hole	Capacity in Gallons Per Hour			
4"	100/250	100/1,100	2,000/5,000	200/1,300
6"	1,000/2,500	500/8,000	4,500/15,000	500/1,500
8"	3,000/5,000	2,500/15,000	5,000/30,000	1,800/5,000
10"	6,000/9,000	12,000/40,000	15,000/58,000	4,000/10,000
12"	10,000/12,000	14,000/60,000	25,000/75,000	

MAINTENANCE OF BOREHOLES AND PUMPS:

69. A properly constructed borehole should have an almost indefinitely long life.

70. Corrosion of the lining should have been provided against in the construction so that the failure of a bore to continue to yield at its maximum capacity is generally due to overpumping in the vicinity, silting or liming up of fissures, or, in the case of screened wells, chemical precipitation on the openings.

71. Silting or carbonate precipitation can be cured by one or other of the methods mentioned under the development of boreholes.

72. Overpumping should be prevented by controlling the quantity of water to be abstracted from an acquifer so that no depletion of reserves takes place.

73. To maintain the purity of the water the head of the borehole should be adequately protected and where possible the immediate area surrounding the borehole should be fenced off to prevent access of animals.

74. Records should be kept of the standing and pumping water levels together with the quantity of water pumped so that any progressive changes can be noted and the requisite action be taken.

75. Chemical and bacteriological analysis should also be made at regular intervals.

76. The output of the pump should be noted in relation to its speed of operation and power consumption so that remedial action can be taken before serious damage is done. This is particularly important in regard to submersible pumps, and if there is any possibility of the water level falling below the pump, low level cut outs should be provided so that the pump is stopped automatically.

GROUND WATER DEVELOPMENT SCHEMES:

77. A brief description of work carried out recently in connection with the production of ground water as a means of supply to towns and villages in Africa and the Middle East will serve to illustrate the type of results which can be generally expected.

TANGANYIKA:

78. The quantities of water obtained from a number of 6" diameter boreholes sunk in the basement complex rocks of Tanganyika in an endeavour to develop water in a rather unpromising area in which little or no weathering had taken place is tabulated below.

79. The borings were carried out by percussion equipment. Four rigs were employed and the average rate of drilling was 127 feet/rig per month. One European driller was employed on each rig and a drilling Superintendent and Agent were in overall control of the work.

80. The work was carried out by contract and the cost of drilling including test pumping averaged £3.6.0. per foot.

"TABLE 5"

No. of Bores drilled	Bores abandoned yielding less than 200 G.P.H.	Yield of Over 1,000 to 2,000 G.P.H.	Successful Bores 500 to 1,000 G.P.H.	200 to 500 G.P.H.	% success-ful
37	16	3	8	7	48%

81. Until the boreholes were developed the country had been barren as there were no existing sources of water supply.

GHANA:

82. To provide rural water supplies in Ghana 10 cable percussion trailer mounted rigs were employed on a contract basis over a period of 4 years ending in 1957. During the four years work 369 boreholes were drilled, of which 301 were successful in that yields of over 100 gallons of water per hour were obtained.

83. As the work was spread over the whole of the northern territory and the eastern and southern parts of the country the rigs were divided into three groups, two of three rigs and one of four. Each rig was operated by a European driller on a single shift basis and each group was under the supervision of a superintendent, with an agent in Kumasi in overall control.

84. One 3 ton lorry and one water tanker was provided to service each group and in addition each rig had a land rover for the use of the driller and for general servicing.

85. Rigs were towed between sites by the lorry or land rover but for major moves the rigs were transported by low loaders.

86. Reciprocating pumps were provided for testing and were rig operated. In certain cases extended tests were carried out by deep well pumps.

87. Work was undertaken for the most part in isolated areas and in many cases villagers constructed access roads to get the machinery onto the sites.

88. The sites of the majority of the boreholes were selected geophysically by the use of resistivity depth probes.

89. Hand pumps were installed in the boreholes sunk in the smaller villages and power pumps of either the reciprocating deep well or submersible types, in the boreholes sunk to supply the larger villages with piped water supplies.

90. The total quantity of water produced from the boreholes was approximately 420,000 gallons per hour or on an eight hour pumping day approximately 1,226 million gallons of water per annum.

91. Results obtained from five areas of different geological formation in Ghana are shown in table 6.

"TABLE 6"

Geological Formation	Bores Drilled	Failures	Successes	% Success	Depth of bore		Max Yield G.P.H
					Min.	Max.	
Mid devonian and Archeon rocks	24	16	8	33.5%	100'	390'	2,500
Cape Coast Granites	44	3	41	93.0%	65'	273'	2,500
Buem Quartzites and Shales	25	4	21	84.0%	120'	360'	3,000
Tertiary and Eretac -ecus formations	22	9	13	55.0%	147'	478'	3,200
Voltaian Sandstone & shale (Damongo)	12	2	10	83.0%	100'	630'	1,200
Voltaian Sandstone & shale (Kete Krachi)	16	4	12	75.0%	91'	280'	3,600

92. Individual results obtained from the forty-four boreholes drilled in one area of the granite formation are as follows:-

"TABLE 7"

No. of bores	Yield G.P.H.	Percentage of Total
19	100/ 500 G.P.H.	43.2%
5	501/1,000 G.P.H.	11.4%
3	1,001/1,500 G.P.H.	6.8%
8	1,501/2,000 G.P.H.	18.2%
6	2,001/2,500 G.P.H.	13.6%
3	less than 100 G.P.H.	6.8%

NIGERIA:

93. In Eastern Nigeria in an area where boreholes range in depth from 350 feet to 900 feet and water is obtained from sands and sandstones rotary equipment has also proved very effective.

94. One truck mounted rotary rig has recently completed 16 boreholes totalling 8,237 feet of 14" diameter drilling in seven and a half months. The average rate of drilling including borehole completion but excluding test pumping, being at the rate of 14.7 feet per 8 hour shift. The best rate of progress was the completion of one 600 foot borehole in 7 days.

95. The yields obtained ranged from 3,000 gallons per hour to 12,600 gallons per hour.

96. Submersible pumps operated on locally generated power were installed to complete the well stations.

CONCLUSION:

97. The examples which have been quoted of work carried out in areas of different geological formations with both percussion and rotary equipment illustrate in some degree the manner and extent to which ground water may be exploited for the benefit of the less fully developed areas.

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Agenda Item: A.4.3.1

United Kingdom

THE CONSTRUCTION AND OPERATION OF SMALL PLANTS, USING LOCAL ENERGY RESOURCES, IN ISOLATED AREAS

By E.W. GOLDING, O.B.E., M.Sc.Tech., M.I.E.E.

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The construction and operation of small plants, using local energy resources, in isolated areas.

By E. W. GOLDING, O.B.E.,M.Sc.Tech.,M.I.E.E.

Introduction.

1. The need for power as an aid to development is now generally agreed. Human labour, even when assisted by that of working animals, can do little more than provide a bare subsistence standard of living except perhaps when employed in certain rural industries with products of a high cash value. For agriculture, which is usually the mainstay of an isolated area remote from centres of population, the only real hope for improvement is through increased productivity resulting from the use of mechanical power. A 1 horse power engine or electric motor is capable of doing 10 or 12 times as much work as a man, or 4 or 5 times as much as a bullock, in the same time.

2. The important question is that of providing such power at an "economic cost", defined as "the cost which will permit consumers of the energy to increase their income by an amount which is at least sufficient for them to pay for it". This will vary according to the remoteness of the area concerned, to the local availability of labour, to the methods of employment and sources of income, to the fertility of the land and possibilities of exploiting the natural resources in the area and on other factors. Although an economic balance may not be achieved immediately following the provision of a power supply, for success the ultimate result must be an overall gain in the income of the population using it.

3. Whatever the actual form of this power, it must either be imported from a distance - as power or as a source of energy from which power can be generated - or provided from local resources. Since the lower the price of the energy consumed, the greater the chance of economy, the problem in practice resolves itself into a comparison between the costs of importing it, and those of employing local sources of energy to generate it.

The costs of imported power.

4. Each of the two methods of importation tends to be expensive. The transmission of electric power involves heavy constructional costs for the transmission lines and, therefore, heavy fixed charges for interest, depreciation and maintenance. The longer the distance of transmission the higher the working voltage needed and the greater the cost, per mile. The fixed charges can be reduced to a small component of the total cost of the energy only if the total quantity supplied is large: for small

amounts of power, transmitted over relatively long distances, these fixed charges represent a major component and may bring about a prohibitively heavy cost per unit of energy supplied. Representative figures for the cost of overhead power lines for short distances - operating at 11 or 33 kilovolts lie in the range of £1000 to £2000 per mile. For extra-high voltage, long-distance transmission the cost is about ten times as much. The result is that the transmission component of the energy cost can be as much as 10 pence per kilowatt-hour, or even more, if an electricity supply with a maximum demand of only a few hundred kilowatts is to be given at a distance of two or three hundred miles from the generating station. Wise planning of a rural electrification scheme can doubtless reduce the lengths of the spur lines needed to distribute power to small villages but, until networks become much more widespread in the developing areas, supplies from local power stations will offer much better prospects of economy.

5. The commonest form of fuel-driven plant used at up-country power stations is, of course, the diesel set ranging in capacity from perhaps 10 or 15 kilowatts to several hundred kW. This is relatively economical in fuel consumption (0.5 to 0.6 pint per horse-power or 0.7 pint per kWh) but it needs skilled maintenance. Although the price of diesel fuel at the ports is usually about 15 pence per gallon, transport to inland stations may double or treble this cost and a representative generating cost at such stations is from 5 pence/kWh upwards.

6. The costs, to the consumer, of imported energy are thus usually too high to encourage consumption on anything beyond a very limited scale, perhaps for lighting and a radio set. Can local sources of energy be used as a more economical alternative capable of satisfying heavier power demands?

Power from local energy resources.

7. These local resources will usually take one of the following forms:- water power, wind power, solar radiation or waste organic matter usable as fuel. All of them have the advantages of being available free of charge and of requiring no transport from a great distance, but they have disadvantages in varying degrees.

8. Water power is very severely limited in location so that the site of a hydro-power station is precisely fixed: again, on a small stream, there may be an insufficient flow of water at some periods of the year.

9. Wind power is less confined in location, but, even so, the most favourable sites must be chosen and these may not be very close to the places where power is needed. More serious disadvantages are the very variable availability of wind power and the low specific energy content of an air stream which thus leads to the employment of a relatively large machine for a given power capacity. The exploitation of wind power may therefore call for a somewhat expensive plant which, inevitably, has a non-continuous output.

10. Plant using solar radiation suffers from much the same disadvantages as wind power: the power falling on each unit of ground surface is rather low so that, for a given capacity, the power plant must be large and relatively expensive and, also, this power is not continuously available.

11. Organic wastes, which can be used to fire a boiler for a steam engine or, alternatively, can be fermented to produce methane, serving as a gaseous fuel, are often unreliable in their quantity at the point where they are needed. If they have to be collected and transported over any appreciable distance they can no longer be regarded as a free source of energy.

(c) Assessment of the potentialities.

12. Since all of these local resources involve the provision of fairly expensive power plant - with fixed annual charges on the investment - the cost per unit of energy generated is largely dependent upon the annual output of energy likely to be obtained. An essential preliminary to their exploitation therefore, is a careful survey to determine their availability, both in time and in place, in the areas concerned.

13. The potential power capacity and annual energy output of a source of water power must be determined by measurements of water flow over a period long enough to serve as a basis for reliable estimates to be made, and these must be accompanied by assessments of the probable civil engineering constructional costs which would be required. Wind power and solar energy potentialities can be estimated fairly precisely from measurements, of wind speeds or of solar radiation, at selected, favourable, sites; again over an adequate period of time which should not be less than one year.

14. The availability of organic wastes can be determined from enquiries at their source while their energy value can be estimated from measurements of their calorific value and experimental work on their performance as producers of methane (by fermentation) or as furnace fuels.

15. The estimation of available annual quantities of energy must be accompanied by a consideration of the availability of the energy source, in time, as related to the probable purposes to which random sources may be applied. Some functions, e.g. water pumping, can be fulfilled satisfactorily at random times whereas others, e.g., lighting, demand availability at night. Storage of energy, to cover periods of non-availability of the source is usually an expensive process and is to be avoided so far as possible. If the random sources can be used as and when they occur the energy provided by them is often reasonably cheap. It is important, therefore, to consider the loads to be supplied as well as the means of supplying them.

(d) Comparative cost estimates.

16. In an endeavour to present comparative costs of energy produced by different means at a remote station, Table 1 has been drawn up. The costs for imported energy can be computed with some accuracy for any required size of plant, or of power demand, at any specified place. Those for the energy derived from local sources are certainly less accurate although the assumptions made in calculating them have been based on the latest available information from organizations concerned with the development of the relevant plant. In addition to the notes

Table 1

Comparison of energy costs.

Form of power	Distance of original source (of the energy) from point of utilization. (miles)	Maximum power demand. kW)	Approx. cost of energy per kWh (pence)	Notes of characteristics and assumptions made
Imported				
Electric, imported by overhead transmission lines.	50	500	3 to 4	Assuming annual load factor of 30% and 15% annual return on capital cost of the line.
		100	10 to 12	
	200	500	10 to 12	
Diesel-electric	50	10 to 100	2 to 3.5	Assuming fixed charges at 20%, diesel fuel costs 15 pence per gallon. Annual load factor 30%.
	200	500	4 to 5	Assuming fixed charges at 20%, diesel fuel costs 30 pence per gallon. Annual load factor 30%.
Petrol-electric	50	up to 10	7 to 9	Annual load factor 30%. Petrol cost 48 pence per gallon.
Local*				
Water power	1	up to 50	0.5 to 5	Assuming capital costs, (including civil engineering) ranging from £100 per kW to £500 per kW, fixed charges as 10% and annual load factor ranging from 25% to 50%.
Wind power	0.5	up to 5	3 to 9	Assuming an average windspeed of 12 m.p.h. and 12½% fixed charges. The upper figure allows for some energy storage.
		5 to 30	1 to 5	Cost of energy depending on annual wind speed and degree of storage.
		30 to 100	1.0 to 2.5	Assuming only limited energy storage.
Solar energy	Neglibibly small	up to 5	1 to 2	For production of heat for water heaters, water distillation, air conditioning etc.
			5 to 10	For motive power when solar engines are in production.
Organic wastes	1	2 to 10	1 to 3	For heating and cooking.
			3 to 6	For motive power from small steam engines.

* Because of uncertainties in the capital costs applicable to the required power plants when these forms of power become commonly used, the ranges of energy costs are wider than those for the more conventional forms of energy given in the preceding lines.

given in the fifth column of the table the following bases of estimation can be stated:-

(a) Water power plant. Capital cost varying from £200/kW for a 10 kW unit down to £40/kW for a 100 kW unit these costs excluding those for electrical transmission and civil engineering work.

(b) Wind power plant. Capital cost varying from £300/kW for the smallest plant (with battery storage) to £100/kW for plant of 100 kW or more in capacity.

(c) Solar energy. Cost for flat plate collectors (which form the basis of solar equipment for water heating, distillation, refrigeration and air conditioning) around £1.5/sq.foot. The energy cost for motive power production is based on information in a paper by H. Tabor (World Power Conference, Melbourne, 1962).

(d) Organic Wastes. Until the costs of collecting the fuel and those of capital cost for a small plant to utilise them, for steam raising or methane production, are known, a statement of energy costs is admittedly little better than a guess.

17. It is perhaps not unreasonable to conclude from the comparison exhibited in the Table, that energy from local energy resources may well compare favourably in cost, with that which may be imported.

Small power plants.

18. Both water- and steam-power plants are well enough established for discussion of their characteristics and performance to be omitted here when the available space is severely limited.

19. Plant utilising solar energy is being developed in several countries and work over the past ten years has already shown that solar water heaters are past the experimental stage. They can be quite economic and some thousands (8000 to 10,000 in Israel) are being installed annually. For water distillation their economy depends on the purpose for which the water is required, upon its salinity and the location of the installation. For refrigeration and air conditioning the economy is at present probably marginal but much depends on the insolation at the place concerned. The economic production of motive power from solar radiation by some form of heat engine, is still some way off in spite of strenuous efforts towards reduction of the cost of the plant needed. The direct conversion of this radiation to electric power, although technically satisfactory, is still far too expensive for use for purposes other than special ones, needing only small amounts of power which could not easily be provided by other means.

20. Research on the development of wind power has been done in Great Britain, during the last 14 years, by the Electrical Research Association. Wind surveys have been made in favourable coastal areas of the British Isles - and in several other countries, under United Nations auspices, following the British method. Several new wind-measuring instruments for the study of wind behaviour have been developed, and, following theoretical and practical studies to determine the best design, a number of pilot plants and prototypes have been built. The latest machines, of 25 kW and 100 kW capacity and built, respectively, by Dowsett Holdings Ltd. and R. Smith (Horley) Ltd., have been tested, during the last three years in the Isle of Man where they are connected to the local electricity network. Details of their construction and performance are given in Table 2 and figure I and the machines are illustrated in figures II and III.

Table 2.

Constructional details of wind-driven generators.

	25 kW machine	100 kW machine
No. of blades	3	3
Diameter of wind rotor	40 feet	50 feet
Hub height above ground	33.5 feet	35 feet
Type of electrical generator	Slip-ring induction generator, totally enclosed.	Standard squirrel-cage induction with fabricated cover.
Blade pitch	Fixed when running: coarse pitch for stopping.	Fixed. Output control by stalling of blade.
Blade construction	Main spar with ribs and aluminium skin.	Aluminium extruded sections.
Method of orientation	By fan-tail.	By fan-tail.
Method of starting	Resistance starter.	Direct-on-line starter for automatic operation. Star-delta starter for hand-starting.
Method of braking	Blades move into coarse pitch.	Disc brake actuated by de-energising a solenoid.
Re-starting after power failure	Manual.	Manual after resetting the brake.

21. It appears probable that, after a further period of running experience to determine the liability of the blades to damage from vibration fatigue and to make such design modifications as may then prove necessary, both of these machines could be made available commercially at an economic price (within the range previously mentioned in 16).

22. While there is no technical difficulty in operating a wind-driven generator connected to an a.c. network into which it feeds its random power output, the operation of an autonomous unit, without a network to maintain its rotation speed at an almost constant value, could be rather more troublesome. For stability, and to ensure full utilization of the available energy, the load should then be continuously matched, as far as possible, to the available power output. This question has been studied experimentally and successful results in operation under normal supply conditions (at an isolated house in the Scottish Highlands) have been obtained through the use of a specially-developed load distributor.

23. An alternative method, when a single load, e.g. water pumping, is to be supplied, is to connect the alternator directly to the load, driven by an induction motor. It has proved possible, by correct choice of the load and alternator characteristics, to achieve satisfactory operation in spite of the varying voltage and frequency of the alternator output caused by fluctuating wind speeds. Similar variations are likely to occur when other small power

plants, e.g. steam-driven sets, are used.

24. Non-electric, water-pumping windmills have been widely used in the drier areas of the world and they present no technical problems of operation or maintenance. Wheel diameters range from 6 ft. to 18 ft. and pumping rates - against a 100 ft. head - from 200 gal/hr. to 2000 gal/hr. in a wind speed of 14 m.p.h. Corresponding costs are 6.5 pence/1000 gal. and 2.5 pence/1000 gal. at a site with an annual average wind speed of 10 m.p.h.

) Effective utilization of local energy resources.

25. The local sources of energy being free (except, perhaps, for the cost of collecting organic wastes), the annual operating costs of the power plants used to exploit them are only the fixed charges - for interest and depreciation - and the maintenance costs, the last being usually quite small because the plants are robustly designed for automatic, or semi-automatic, operation. It follows, therefore, that the more fully the plant is used the lower the cost per unit of energy. The plant must not stand idle, or only partially loaded, when adequate power is available to it: useful loads must be found. This is the function of the load distributor already mentioned. It automatically "shunts" power to one or more of a group of selected loads, e.g. for water pumping, heating or cooling, automatic grinding of foodstuffs etc., whenever there is enough power available. These loads must, of course, be chosen from among the many which can be supplied at any time of the day or night, acting as "sinks" into which energy can be poured. They are a cheaper alternative to storage devices which, while certainly needed to cater for high-priority loads at certain specified times, undoubtedly add considerably to the cost of that part of the energy supplied through them.

26. Automatic load distribution can be done conveniently only when the power has been converted to electrical form and, although all the local sources of energy could be applied to the generation of electricity, direct utilization, without such conversion, may be more economic. An obvious example is the use of solar water heaters. It may well be, therefore, that the best way to use these sources would be in combination, allowing each source to supply the loads for which its characteristics are suited. Random sources of power such as wind or solar radiation can be "firmed" by more continuously available sources - water power or power from organic wastes which can be stored for stand-by purposes.

Conclusion.

27. The research and development work done during the last decade has proved that there is scope for the use of small, locally-powered, plants as potentially economic producers of energy. For some forms there is little more research to be done: for others much is needed. The difficulties being faced are clearly not insuperable but the application of such plants to practical purposes calls for careful consideration of (a) their design in relation to their intended location and use; (b) the combination of suitable types and sizes best suited to the requirements; and (c) the choice of sites for experimental schemes in which the use of the power by local inhabitants can, in the early stages, be adequately supervised by representatives of development authorities. The establishment of one or two experimental schemes to test the potentialities under entirely practical conditions, would provide much information which is essential if the exploitation of these local energy resources is to make any progress in the near future.

Fig. II

25 kW wind-driven generator
under test in the Isle of Man

Fig. III

100 kW wind-driven generator
under test in the Isle of Man

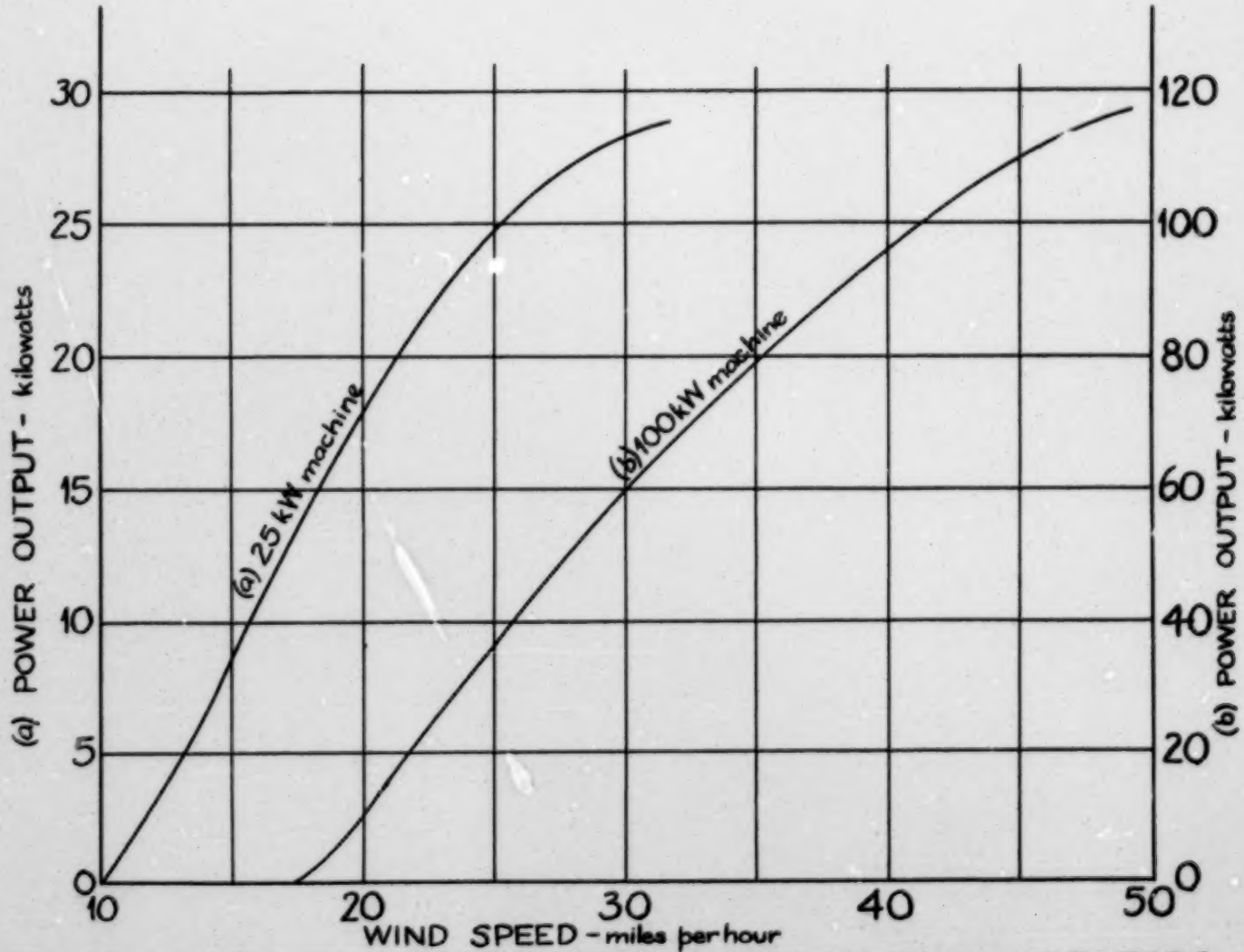

Fig. I. OUTPUT CURVES OF 2 WIND-DRIVEN GENERATORS

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MODERN TECHNIQUES APPLIED TO THE DESIGN AND CONSTRUCTION OF THE HIGH ASSWAN DAM

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

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MODERN TECHNIQUES APPLIED TO THE DESIGN AND CONSTRUCTION OF THE HIGH ASSWAN DAM

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I. RECONNAISSANCE SURVEY FOR UTILISING THE FLOOD WATERS OF THE NILE TO THE BEST ADVANTAGE

1, The flow of the river Nile, like other rivers in the world is fickle and unsteady, being governed by intricate climate conditions as yet uncontrolled by man. Its variable supply may be short of irrigation requirements as to threaten the country with the danger of stravation or may be so high as to cause destructive innundations.

2. Since a very early period the problem of harnessing the flow of the Nile for the better security and prosperity of the people of its valley has always engaged their serious attention. The problem was mainly that of regulating the flow so as to avoid the extreme fluctuation of drought and flood and of obtaining the maximum benefits inherent in its potential resources.

3. During the last one hundred years, much has been done to conserve the waters of the Nile for irrigation purposes but up to the present time a large amount of each annual flood still flows to waste into the sea. The amount passing to the sea is, however, very variable being almost nil in the lowest year and as much as 100 milliards of cubic meteres in the highest.

4, For the design of any control project on a river, accurate and detailed information about its regime of flow should be obtained. On the Nile we are more fortunate than many other countries where water development has only recehtly become important, and in many cases, only few observations covering a very short time exist.

5. In Egypt, records on the Roda Island gauge in the Nile near Cairo go back to nearly 1000 years. Though the value of its readings is considerably reduced by the difficulty in following the various repairs and reconstructions which the gauge has undergone, yet the records were good enough to give an idea of the periodicity of high and low floods. With very few exceptions, the maximum levels of the Nile at Roda were recorded for each year since it was erected up to the present day. Again the early gauge which was built at Asswan is a standard gauge indication the true state of the river level since 1869.

6. The scientific study of the Hydrology of the Nile actually began after the construction of the original Asswan Dam in 1902, when current meters were first introduced as a means of measuring

the quantity of water flowing in the Nile and for the first time the Blue Nile and White Nile were accurately measured and their relative discharge proportions discovered.

7. Many observation stations in many of the important localities along the Nile were established to collect more information about its sources. This, however, was not easy task for a river whose length exceeded 6000 kilometers going through the countries of Kenya, Tanganika, Congo, Uganda, Abyssinia, Sudan and Egypt. All these studies were conducted mainly by the irrigation department of Egypt because although the other countries are in one way or another affected by the river, none of them entirely depends on it as much as Egypt does.

8. As a result of the large number of observation stations constructed at the different reaches of the river and its tributaries for the registration of water levels, discharges and rainfall, a large amount of data has now been collected and our knowledge about the river has now increased to an extent not very far from perfection.

9. It was in the light of these observations and information that all the hydraulic structures on the river were constructed including the existing Aswan Dam, the Gabel Awlia Dam near Khartoum, the Sennar Dam on the Blue Nile, the Victoria Lake Dam and other big barrages on the Main Nile from Aswan to the Meditterranean Sea. It was on the basis of these observations also that the hydrological investigations for the present High Aswan Dam Project were successfully conducted.

10. During the last ninety years, available records of the Nile water supply revealed that the flow varied considerably from year to year. While the annual water requirments for irrigation of the present cultivated area in both Egypt and Sudan are 52 milliard cubic meters, the natural flow of the river reaching Aswan may be as low as 42 milliards of cubic meters as it happened in the year 1913-1914 or as high as 151 milliards as it happened in the year 1878-1879. Again, while the present requirements in Egypt during summer season are estimated at 22 milliards of cubic meters, the supply of the river in this season dropped to 7 milliards in the year 1914 and reached 36 milliards in 1879. These two contrasting cases explain the extent of the importance of the variations so far as irrigation requirements are concerned and make an urgent solution of this problem an imperative necessity. The only solution to these problems is to provide over-year storage by building reservoirs large enough to store the excess waters in all years to make use of them in time of shortage and in succession of low years.

11. Comprehensive surveys which were made by many competent technical authorities in Egypt have shown that there is not a single site on the Main Nile more suitable for a large capacity reservoir to store all flood waters of the river other than the site at Aswan.

12. It was therefore decided to construct a high dam at Aswan with a storage capacity of about 130 milliards of cubic meters, of which 30 milliards will be alloted for the accumulation of sediments in suspension of flood waters, 70 milliards for live storage and the upper 30 milliards for flood protection. According to calculations based on current theories of over-year storage, the live storage capacity of the reservoir is sufficient to provide a constant annual draft of 84 milliards of cubic meters of water which represent the average annual flow of the Nile at Aswan during the last sixty years of actual flow records.

As the average unavoidable losses from the reservoir is estimated at 10 milliards of cubic meters per year, the net guaranteed annual draft from the new reservoir will be about 74 milliards. According to the recent agreement made between the UAR and the Sudan, Egypt's annual share will be 55.5 milliards and that of the Sudan 18.5 milliards. At present these shares are 48 and 4 milliards respectively.

13. Further conservation projects for the waters of the river are possible on the Upper Nile reaches to deal with the clear waters, but these projects will only add at Aswan about 5 milliards of cubic meters of water, now lost annually in the swamps, but do little to equalise the variable flow of the Main Nile in flood season.

14. This shows clearly how the over-year storage of the flood waters achieved by the construction of the High Dam is an energetic approach to control the water resources of the Nile for the expansion in cultivation, production of electric power and other multiple purposes. In fact it is a large step towards the full development and utilization of the waters of the Nile to the best advantage.

II. TECHNIQUES APPLIED IN THE SELECTION OF THE DAM SITE

15. The selected site for the construction of the High Dam at about 7 Kilometers upstream of the existing Aswan Dam is ideal and looks as if it was made to order for the construction of a High Dam. It has the advantage that both its banks rise steeply from the river bed so that a dam of only moderate length would be required and at the same time has a very wide and deep valley on the upstream affording an excellent storage capacity.

16. An extensive programme of drilling boreholes in the river bed at the selected site was carried out accompanied with extraction of a big number of disturbed and undisturbed samples of the overburden materials. The undisturbed samples were extracted by the freezing method. This programme was set for investigating the overburden lying on the solid rock of the trough of the river and to determine its thickness, kind, density of stratification, permeability and to find all physical properties of the samples by performing necessary tests.

17. As a result of grain size analysis of the extracted samples, the upper stratum of the overburden consists mainly of sand and fine medium gravel. At depths below 35ms of this upper stratum, the overburden becomes particularly coarse containing but a small sand ratio. The lower stratum of the overburden consists not only of loose sand and gravel but there also exist clay lenses and petrified sand layers. The surface of the igneous rock below this stratum was found to form a U shape with the deepest point at about 210m below river bed.

18. These subsoil explorations as well as other technical investigations on the river banks revealed that the topographic, geologic and hydrologic conditions at the selected site of the dam lend themselves well for the construction of a very safe high dam.

19. For the estimation of the reservoir capacity an aerial survey covering the reservoir area was made. Control points necessary for drawing up the topographic maps of this area were fixed by the Egyptian survey department.

III. SELECTION OF THE TYPE OF THE DAM

20. At first many difficulties were associated with the design of the dam as it has to be constructed on a pervious foundation in the lake of the existing Aswan Dam where the depth of water exceeds 35m. Again, the quantity of water which will pass at the dam site during its construction may assume in flood seasons volumes up to 11,000 cu.ms. per second.

21. In fact the natural features of the site offered insurmountable difficulties in regard to the construction of a concrete dam. On the other hand, these features, as well as other conditions concerning the availability of suitable construction materials in the vicinity of the dam site, were practically favourable for the realisation of a rock-fill dam.

22. Several important problems bearing principally on the stability of the dam and on the seepage losses were carefully studied before the engineers came to the successful conclusion that a rock fill dam could safely be built at the selected site.

IV. EXPLORATION OF LOCAL CONSTRUCTION MATERIALS

23. The exploration made for the local materials of construction in the vicinity of the proposed site showed that there are enough quantities for all main materials required for the construction of the proposed rockfill dam with its central clay core. Borrow pits were excavated to explore the suitable material for the impervious core and the horizontal impervious blanket of the Dam. It was found that it can be made out of Nile silt. Large deposit of this silt is located at Bahrif Island which lies about 22 kilometers north of the proposed site of the High Dam.

24. The rock material which will be obtained from the open rock diversion canal and spillway tunnels will be used in the construction of the rockfill part of the dam. Additional required quantities of rock can be obtained from quarries within a moderate distance from the dam site.

25. Dune sand required for the upstream part of the dam is available in unlimited quantities on the west bank of the Nile. Full adequate coarse grained filter materials can be obtained by a process of crushing and screening from the tunnel muck.

26. The coarse sand required for the concrete parts and for filling downstream of the central core of the dam is available at Shellal which lies at about 10 kilometers to the north of the dam. The clay required for grouting operations can be obtained from the clay quarries in the Nubian sandstone near Aswan. The available quantities are far in excess of what will be needed.

27. All materials of construction have been subject to laboratory tests and yielded satisfactory results. The coefficient of permeability of the Nile silt ranges between 1.2×10^{-8} To 8×10^{-8} cm/sec. and its optimum moist content ranges between 20 & 26. Thus it has proved to be suitable as an impervious core material.

28. A summary of the quantities of the local materials of construction involved in the construction of the project is as follows:

Placement of rockfill	27,000,000 m^3
" " dune sand	5,500,000 "
" " coarse sand	3,500,000 "
" " Nile silt	2,500,000 "
Filters	500,000 "
Aswan clay	500,000 "
Concrete and Reinforced Concrete..	500,000 "
Total...	40,000,000 m^3

V. TECHNIQUES APPLIED TO THE FINAL DESIGN OF THE DAM

29. After very careful studies of the foundation conditions and of the proposed methods of constructing different water cut-offs it was concluded that a rockfill dam equipped with a clay core, an upstream blanket and a grout curtain with the dimensions proposed will be as safe as the safest among the existing earth and rockfill dams resting on sediments because it will be protected against piping by two lines of defence; an upstream blanket and a grout cut-off.

30. According to the proposed design, the height of the dam is 110 meters above river bed, its width at the base 1000 meters and the length of roadway at its crest is 3500 meters. It will consist of three main structures; the upstream cofferdam, the main dam and the downstream cofferdam. The upstream cofferdam will serve the function of diverting the entire flow of the Nile during the construction of the main dam into the diversion canal which is now being cut on the east bank. It will be made of rockfill slui-oed with sand. The whole extent of the foundation of the main dam will be covered with a layer of compacted dune sand. The rockfill above this layer will have a clay core made of Nile silt. In the pervious bed of the river, a grout curtain will descend to a maximum depth of about 210 meters until it strikes natural bed rock. When this grout curtain is completed, it will be about 40 meters deeper than the world's present deepest grout curtain, that under the Mission Dam in British Colombia. The downstream cofferdam will be built of rockfill to prevent deposit of silt on the river bed at the site of the main dam Together with the upstream cofferdam, it will allow for the construction of the main dam in still water and will both remain an integral part of the main dam.

31. In order to furnish adequate information concerning the practicability and efficacy of the modern techniques applied to the design and construction of the dam, the following field tests were performed on site:

a. Grouting tests by injection of different admixtures of claycement and clay-silicate grouts in the sediments forming the river bed.

b. Compaction tests in submerged dune sand-fill by the use of internal deep vibrators and by blasting.

c. Compaction tests on core material by depositing layers of Nile silt and compacting them by heavy sheep - foot and peneumatic rollers.

d. Compaction tests of the material of the upstream impervious blanket by depositing separate layers of silt and stones and vibrating them by mammoth vibrators to form a combined layer of clay rockfill.

32. All these local field tests proved to be successful and informative. The information collected during their performance revealed that the test arrangements have served their purpose to perfection and the theories used for interpreting the test results were as rigorous as one can reasonably expect.

33. Grouting test in the parts of coarse and fine sands in the river bed gave the following results:

	Coefficient of Permeability Before Injection	After Injection
Coarse Sand	2.5×10^{-2} cm/sec.	2.3×10^{-4} cm/sec.
Fine Sand	6.1×10^{-3} cm/sec.	3.6×10^{-4} cm/sec.

34. However, experience in many of grouting works in other constructions has revealed that independently of the initial permeability of the sediments and their nature, the permeability cannot be reduced below certain limit. This limit is in the vicinity of 10^{-4} cm/sec and varying according to the different cases between 5×10^{-4} to 5×10^{-5}. Therefore, it can be concluded that in terms of absolute values. the permeability of the sediments forming the river bed under the High Dam obtained after injection appears to be very near the limiting value that is possible to achieve.

35. The results of the internal vibration tests on the submerged dune sand-fill indicate that while the penetration resistance at 14m. dpth in the sand-fill under test was about 60kg/cm. it was possible, after compaction, to increase this resistance to more than 400 kg/cm at a depth of 4.5m. measured at the insertion points. The results of compaction tests by blasting revealed that in order to reach the specified penetration resistance too many blasts would be required and would therefore be less economic than compaction by vibration.

36. Compaction tests on core material by using sheepfoot rollers have shown that the best compaction was attained by depositing layers of silt not exceeding 25 cm. at a moisture content of 22-25% and compacted by 8 to 10 passes. Inferior results were obtained by using pnuematic rubber tyred rollers and vibrating plates.

37. Visual inspection after carrying out the compaction tests on the clay-rockfill material showed that all voids between stones are densely plugged with Nile silt. Laboratory tests proved that the permeability coefficient was about 2×10^{-6} cm/sec.

VI. METHODS OF CONSTRUCTION USING LOCAL LABOUR

38. The excavation of the open rock diversion canal, in itself, is a formidable job requiring the excavation of more than 9 million cubic meters of hard gran te. The higher rock cliffs at the site of the canal were blown off by the standard method of driving horizontal adits and chambers inside the rock. The charging and blasting of dynamite in these chambers enabled the removal of all the higher parts of rocks, thus forming horizontal benches at different levels. On these benches, drilling rigs are installed to drill vertical holes which are charged with dynamite for the removal of rocks.

39. For the blasted rock delivery up to the dump area, the possibility of using motor trucks or railroad transport was dicussed, but it was found that the use of railroad transport, though being technically possible, is considerably more complicated from the organizational point of view. Therefore, it was decide to use for rock transportation dump trucks with load capacity corresponding to the 4 cubic meter electric shovels now used at site.

40. Rock excavation in the main canal portions is executed in layers making successive headways. Each bench excavation begins from a cut trench 25m wide made by the face method to facilitate truck manoeuvering and for increasing the equipment capacity. The rest part of the bench is removed by side headyways. Bench height has been accepted to be 12m whose value is supposed optimal for the given conditions. Increasing of the height entails diminution of the working front and therefore prolongation of the completion time. On the other hand, acceptance of the less height of the benches would entail an extra road construction works and would decrease use of equipment and blasting factors. For the available equipment, the 12m bench height is also the most convenient considering the blasted mass collapse conditions, and from the point of view of the shovels excavation height.

41. Rock blasting in the open canal is executed by bore-hole charges method in which holes are drilled in the rock to the required depth, filled with dynamite contained in water proof cartridges, and then electrically blasted by short-delay detonators. For the proper channel walls execution, the initial excavation is provided not for the full cross section but leaving the side prisms about 2m wide for petty-holes drilling and blasting. The blasted mass is thrown down to the face bottom and, after heaping by bulldozers, is loaded by excavators into trucks.

42. The shovels operation are provided in two shifts with the third shift being released for the blasting and other auxiliary and preparative works. The total rate of progrss of work does not decrease under such regime.

43. All the rock excavated from the canal is stored in dump areas from where it will be reloaded for use in the construction of the first stage part of the dam including the upstream and downstream cofferdams.

44. The number of the local skilled labour employed for the excavation works in the open canal has reached 1400. They are of the well trained workers having the following specialities:

Metal cutting machine operators
Motor, machine, compressor, pump and dump truck operators
Black smith presser
Copper and tin smith
Fitters (elec. and mech.)
Carpenters
Elec. and gas welders
Crane operators
Drivers
Oxygen station operators
Bulldozer and tractor operators
Excavator operators
Drilling rig operators
Driller by perforators
Drill dressers
Electricians

Blasters
Tyre repair workmen

The number of specialised local labour is expected to increase to 2000 during the next few months.

45. By the conditions of rock excavation in the open canal, the parts of the canal adjoining the control tunnels could not be excavated to the bottom level before 2 years. That is why for simultaneously construction development in the spillway underground structures, work is now proceeding in driving a special transport tunnel of about 600m long. The width of this transport tunnel is 10m to accomodate 5 ton trucks for two-way traffic. The height of the tunnel is 7.5m. It was determined by drilling platform dimensions and on the account of ventilation pipes placement, where the geological break areas are crossed by the tunnel, concrete, lining of the vault is made. The part of the transport tunnel from its entrance to the crossing of the first control tunnel is driven with 10% gradient to allow for easy transportation of muck and concrete by cars. The tunnel excavation is carried out by full-face rock tunneling methods. The drilling of bore-holes is performed by high speed drills from 2 drilling platforms. The muck loading into the 5 ton dump trucks is carried out by electric excavators having a shovel capacity of 0.65 cubic meters. Drilling and loading are not executed at a time.

46. The six spillway tunnels each with a diameter of 15m, have a design excavation area of 215 square meters. Considering its great height the tunnel is excavated in two successive stages by the top-heading method. Initially the top-heading of 100 square meters area is driven, then the vault is concreted and afterwards the bench of 115 square meter area is excavated. The top-heading height is determined by the accepted shovel placement condition. Such coordination makes it possible to use for driving the bench the same shovels and trucks as those used for the top-heading. For loading the blasted rocks and their removal in both parts, the same types of electric shovels and dump trucks for excavation of the transportation tunnel are used. Rock scraping after blasting in the tunnels is performed by bulldozers. The empty trucks manoeuvering in the tunnel is executed without any auxiliary means because the tunnel dimensions are sufficient.

47. When there are separate fissures in the rock and the falls out become possible, the tunnel vault and walls are consalidated by rock bolts. These bolts are up to 3m long and 25m/m dia drill steel. They are spaced at approximately 2m in chess-board order and connected by steel plates. The fissured rock is also consolidated by spraying concrete directly on the rock or above a mesh fastened by bolts to the surface. The average thickness of the concrete layer is 5 to 10cms. but in separate cases it may be increased up to 20cms. The length of the unsound rock areas subject to consolidation by steel plates is accepted in the design to be not more than 10% of the total tunnel length. The length of the parts additionally consolidated by spraying of concrete is also accepted to be 10%.

48. The number of local skilled employed in the excavation of the tunnels is 400 and will soon reach 600. Most of these local labour workers have similer specialities as those employed in the excavation of the open canal with the addition of concreters and reinforcementworkers

49. According to the design, the rockfill forming the upstream cofferdam will be sluiced with dune sand. Also the foundation of the main dam involves the placement of a big quantity of dune sand fill. A Hydromechanized system is now used for stacking the quantity of dune sand required for sluicing and filling both parts of the dam. Four big pump units are installed on barges in the river, each capable of lifting 4700 cubic meters of water per hour at a static head of 9 atmospheres. The pumped water is delivered to the dune sand borrow-pits, existing on the west bank of the river, through 800% pipe lines equipped at their end with hydromonitors to wash out the sand from quarries and gather it in the low places and ravines in the areas. From these places the 10 to 1 water sand mixture is pumped again and delivered through 450% pipe lines to an intermediate stacking area specially arranged so that its minimum level is higher than the required level of the sand filling. This intermediate stacking has to be stocked up well in advance to avoid excessive increase in number of hydromonitors at a short period of intensive sand filling consumption.

50. The quantity of dune sand which has been so far piled in the stacking area is about 1,250,000 cubic meters out of the total quantity of 4,600,000 which is required for sand filling works. The stacked dune sand will have to be washed out again by hydromonitors and the pulp of sand and water will flow by gravity through an 800% pulp pipe made on pontoons to the rockfill body.

51. The number of local labour employed at present for the delivery of dune sand by the hydromechanization system has reached 200 well trained workers of different specialities including metal cutting operators, pump operators, blacksmiths, fitters, carpenters, painters, crane operators, bulldozer and excavator operators, wood cutting machine operators, electricians and water jet operators.

VII. MODERN TECHNIQUES APPLIED FOR OVERCOMING DIFFICULTIES IN THE CONSTRUCTION OF THE DAM IN DEEP WATERS.

52. The upstream cofferdam, which will constitute a dam across the river of 50ms high, will have its core built up of rockfill with a wedge shaped body of dune sand on its upstream side. The main difficulty in the execution of work for this structure is its formation in deep waters within the present Aswan Reservoir area, where the depth of water for a large part of the year remains at 30 to 35 meters. In flood time, however when the reservoir is empty and the depth of water is small big flood velocities do not allow placement of materials.

53. According to an old design, the cofferdam was to be erected by first laying filters under water at depth up to 35ms. This work is the most important and most difficult of all works that have to be done during the first stage of construction. However, it was found that there cannot be a reliable control over such kind of work. If small sections of the bottom are left uncovered by filter, they would be very difficult to discover at such a depth under water. After construction of the rockfill cofferdam and the head of water applied on it, the sands of the river bed at these sections may be washed away, which might lead to disasters. Also when filter material is dumped into the river, its particles will be carried off downstream. The movement of the different sizes of the particles of the filter material will vary with the velocity of the stream. This will impair the quality of the filter and make the dam less reliable.

54. In order to overcome these difficulties some changes in the design of the cofferdam have been introduced. It was decided not to lay filter layers on the river bed. The rockfill of the upstream cofferdam will be dumped without filter on the bed of the river and the cavities between the stones will be plugged with sand applied in the form of pulp. The sand will fill up all the pores in the rock and therefore placement of filters in the bottom could be dispensed with. The sand has to be dumped in the river along its entire width upstream of the dumped rockfill and a head of about two to three meters should be created on the rockfill dam to help penetration of sand by the water current through the pores.

55. Experiments have shown that the sluiced sand into the pores of the rock becomes compacted by itself and moves from higher to lower levels and that infiltration through the rock-sand body is less than that through sand alone. At the same time, it is not subject to big settlement as sandfill.

VIII. PROGRESS OF WORK

56. On the 9th of January 1960, the President of the UAR blasted the first charge of dynamite for the excavation of rock in the diversion canal. This marked the historic opening of the work in the project whose completion necessitates 8 years of digging and building. Before the official start of work was announced, however, the main enphasis on construction was the establishment of the scheme and carrying out preliminary construction works. After the inauguration date, there has been a constant direction of work to the dam site and speeding up of progress on the preparatory works, site services as well as on the permanent works in particular the diversion canal.

57. Preparation for the construction of the dam involved the extension of an access railroad to a distance of about 15 kilometers and the construction of several long hard surfaced highways of about 40 kilometers, electric supply lines at 132 kv of 12 kilometers, transformer substations and many living centres consisting of about 3000 rooms complete with water supply, drainage, electric lighting air conditioning ice plant, etc.

58. For the construction of the permanent works, big workshop installations and other site facilities were put into position. They included mechanical and car maintenance workshops, water supply systems, air compressor station, crushing and screening plant, concrete workshop and batching plant, oxygen plant, cable ways and many stores and erection yards.

59. The diversion channel on the east bank of the river is now under excavation. The total length of this channel including the upstream and downstream open rock parts, the spillways structure and the power house is 1835m. The schedule of work is pegged on making the river diversion through this canal in the spring of 1964. Up to the end of July 1962, 4.5 million cubic meters of rock have been excavated representing 50% of the total canal excavation. The present rate of excavation is about 12,000m3 per day and is expected to increase to 14,000. The quantity of the locally produced explosives which has been so far used for the excavation works reached about 1600 tons of dynamite.

60. In the middle part of the channel, work is about to be completed in the 600 meters transport tunnel leading to the six main control tunnels. The width of this tunnel is 10m. thus allowing for two way traffic of the trucks used for the removal of rock from the main tunnels. Work has already started in the excavation of two of the main circular tunnels, each of 15m diameter.

61. At the inlet of the diversion canal a temporary cofferdam of about 20m high and 250m. long was made of dune sand-fill. The filling of the 250,000m3 of dune sand forming this cofferdam was carried out by the use of the hydromechanization installations.

62. Several contracts have been awarded to contractors for the execution of the first stage works of the dam which, according to the schedule will be completed in 1964. For the excavation of the open canal and the foundation of the hydro-electric power station the construction of the upstream and downstream cofferdams, the formation of the right wing of the main dam as wall as the constuction of other ancillary works, a contract was awarded in March 1961 to a joint company of local contractors for LE. 15,760,000. Concrete works of the power station and of the intake portals of the control tunnels were entrusted to a local company specialised in concrete works for LE. 4,013,000.

63. In the meantime, investigation works including topographic and geologic studies of the routes of the electric lines for the transmission of power from the High Dam Hydro-electric Power Station to Cairo are proceeding. This network transmission scheme involves the erection of two 900 kilometers electric supply lines at 500 kv as well as 1000 kilometers of 132/220 kv lines.

64. The total cost of the High Dam Project is estimated at about LE. 215 millions of which LE.40 millions have been spent until the end of July 1962.

65. The number of Arab Engineers who are at present working on the project is 150. At the construction site at Aswan a trade school programme is established to train Arab equipment operators, technicians and foremen with special emphasis on safety. To meet all demands, the total local labour force at the construction site has exceeded 12,000 men.

428 E - Oct.1962 - 1,600

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Agenda Item: A.1.

United Arab Republic

ON THE PROBLEMS ASSOCIATED WITH THE ADOPTION OF MODERN SURVEY TECHNIQUES IN THE DEVELOPING COUNTRIES WITH PARTICULAR REFERENCE TO EXPERIENCE IN U.A.R.

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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ON THE PROBLEMS ASSOCIATED WITH THE ADOPTION OF MODERN SURVEY TECHNIQUES IN THE DEVELOPING COUNTRIES, WITH PARTICULAR REFERENCE TO EXPERIENCE IN THE UAR

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PREFACE

1. When the present survey of Egypt came into being in 1895 its first task was to push on the cadastral survey in order that the re-assessment of the whole country for land tax might be completed within ten years. This task was so urgent that there was no sufficient time to permit for mapping being delayed until a unified geodetic framework could be established. Discrepencies appeared between the sheets of independently surveyed regions; and the need of a revision of the cadastre was soon felt. The second cadastre was started in 1921 to make new maps at the scale 1/1000 and the new surveys were adjusted to fit into the second order triangulation which had then covered the cultivated regions.

2. The geodetic network across the Nile from Cairo to the frontier of the Sudan Republic was established in the years 1907-1930, and the two branches from Cairo in the NW and NE directions were completed in 1945. Precise levelling commenced in 1906, to establish fundamental bench marks over the cultivated lands to enable the whole of the irrigation system of the Country to be referred to one common datum. Owing to lack of experience much of the work carried out before World War I was not up to the international standard of high precision levelling. A new network was therefore embarked upon and completed in 1936.

3. The economic policy prevailing at that time paid little attention to the desert regions. For military purposes however, a series of topographic sheets at the scale 1/100 000 was started in Sinai and extended to serve as base maps for geological exploration in search of mineral resources by a few foreign companies. To control the plane table work triangulation points of a special class were observed, and the scale was checked by means of measured short bases. The heights were determined from vertical angle measurement.

4. When World War II came to an end, and after fifty years of most creditable toiling, the cadastral survey had covered 40% of the cultivable land, the 1/25000 sheets of the green region were complete but needed revision, and eighty townships had been mapped but many more had no maps and the older sheets were out of date. We also had topographic sheets at the scale 1/100 000 for 40% of the total area of the Country, but some of the sheets were not contoured. The size of the work which remained undone clearly showed that the traditional field methods could not possibly fulfil the normal survey programme of the Country fast

enough to match the post-war pace; and we set to study the possibilities of aerial surveying and electronic distance measurement.

5. It was also clear that the Country was not likely to endure the prevailing political and economic conditions for very long. The great political activities at home culminated in the overthrowing of the old regime and the emergence of the Republic, with new concepts of economic development and social progressiveness, making further heavy demands on the survey establishment for their implementation. The most important were:

(a) The execution of the Agrarian Reform Law (1952) which set an upper limit to the area of individual holding, called for survey operations in scattered areas covering some 500 000 feddans (One feddan equals 4200 square metres or 1.04 acre). Difficulties arose in the areas which had not been reached by the second cadastre, for the areas calculated from the old maps were incorrect in places.

(b) Survey operations extending over 380 kilometres from Aswan to Halfa, for the High Dam hydro-electric scheme.

(c) Land reclamation projects in various places involving the contouring of over 500 000 feddans.

(d) The survey operations required to convert to public property the land required for the construction of irrigation and drainage systems, roads, schools, hospitals and social centres. The projects which necessitated the expropriation of land and the compensation of the proprietors increased from about 200 in the twenties to an average of 650 in the last ten years, reaching the peak value 1228 in the year 1955-1956 shortly before the Suez campaign.

6. When these tasks rushed in, the Survey Department had not the chance to adequately equip itself for the efficient use of modern techniques; and the completion of all these tasks in time was beyond its capabilities. The aerial survey of the High Dam project was therefore carried out abroad. In the meanwhile the number of field parties was increased to meet the heavy demand for 1/2500 contoured maps for the land reclamation projects, and the survey school, which had been temporarily closed, was reopened to train field surveyors. But we never lost sight of the need to modernize the whole survey system to cope with the mapping requirements of the Country. These range from the simplest form of charting the unsurveyed regions to the most detailed and accurate surveys for cadastral sheets, town maps and engineering works in topographically varied regions.

7. As some of the factors which made progress rather slow in the beginning are likely to recur in other countries I propose to treat them in general terms. Examples from experience in UAR will be discussed to show how these difficulties were approached.

FACTORS LIMITING THE USE OF MODERN SURVEY TECHNIQUES IN THE NATIONAL CARTOGRAPHIC UNITS

Capital and foreign currency.

8. Problem No 1 is the cost of the instruments. We must admit that the prices of photogrammetric and electronic measuring instruments are becoming rather prohibitive for the smaller countries. Even the so-called moderately priced units so outstep the imagination of those who are accustomed to budgeting for theodolites, levels and plane-table outfits that it is often an ordeal to persuade them to consider the worthiness of the endeavour to modernize the survey techniques. The situation may be aggravated by the intervention of some veteran of the old school who would argue that, given a few more men and a few more trucks, he would handle the job more economically and just as fast.

9. This problem was partly solved by inducing other government offices to allocate some of the funds available for mapping projects to the purchase of equipment for the Survey Department, thus helping to build up a survey potential which would meet any future demands from them. Shortage of foreign currencies is a serious handicap. We have learnt that we should put up with it and be prepared to do better than insist on specifications which fit only one make.

The level of the local technical potential.

10. The second hindering factor is likely to be the low level of the local technical potential. It is easy enough to train young people with some secondary school education to operate the most modern survey equipment when these are in good working conditions; but it may be difficult to find the person who can locate and adjust the faulty component when the performance of one of these instruments falls below the permissible limit. The fault-finding charts do not solve all the problems; and the attempt to check and repair the instrument may be thwarted by the presence of small differences between the actual construction and the description given in the manual of operation.

11. It is of course true that certain repairs and adjustments must be made in the factory. One may also expect that only the experienced technicians of the makers have sufficient knowledge of the design, construction and expected performance of every component; but we must be aware of the difficulties which we would meet if our production is made to depend, entirely, on equipment the intricacies of which defy the technical abilities available at home.

Organizational difficulties.

12. The adoption of modern survey techniques meets many organizational difficulties arising from the lack of appreciation of the full impact of modern technology on the art of surveying. It must be realized that modernization is not achieved by the mere annexation of a photogrammetric laboratory and the purchase of a few electronic instruments. The whole establishment must be remoulded so that the air survey division embraces all the elements which are necessary for its proper functioning, including the photographic laboratories, the field sections, a computing division, and the drawing offices. Otherwise the activities of the photogrammetrists may be frustrated. It is also noteworthy that instruments

end operators, alone, do not make an efficient survey unit. The true index of productivity is the proficiency of the technical supervisors. These are the most difficult to make an efficient survey unit. The true index of productivity is the proficiency of the technical supervisors. These are the most difficult to make, but they are indispensable.

PROMOTING FACTORS

International cooperation and technical assistance from the more developed regions.

13. The emergent countries naturally look at the United Nations Organization and the highly developed member states for help to overcome these difficulties. In some cases, however, the granted assistance takes the form of financial support to contract mapping projects to specialized commercial companies. This may solve an immediate problem and it may infuse an appreciation of modern survey methods; but it is hardly the way to build up a national experience in surveying and cartography.

14. Joint projects in which personnel from the recipient country take an active part are of greater value to the long-term technological development. An interesting example from a related field is the soil survey project which is still in progress in the UAR. The agreement with FAO allowed for both

(a) the employment of technical experts to help conduct the operations and to train Arab agriculturists, and

(b) scholarships to study the subject abroad.

Similar arrangements would help establish national cartographic units, but the take-over must be intelligently planned, in order that the lively establishment may not degenerate into lonely instruments in closed rooms after the visiting experts leave for home.

15. To my mind, a very effective way in which the international organizations can help promote the application of modern survey techniques for the benefit of the developing countries is to establish regional training and research institutes. These will at once solve the problem of training recruits from the neighbouring countries and help to tackle the local problems which crop up in the course of production.

The development of adaptable simplified techniques.

16. Under the conditions prevailing in most of the emergent countries, an appraisal of the possibilities of the simple methods of surveying from aerial photographs is opportune. The problem of transferring the topographical features from the aerial picture to the base map has a number of satisfactory solutions employing simple tools such as the sketchmaster, single projectors, and the plotting devices that are based on the radial line method. The slotted template method serves for the control of the scale.

17. The development of a photogrammetric method of height determination and contouring by means of simple instruments is fundamentally more difficult, because of the greater practical significance of height errors. Several graphical and numerical methods were proposed for the computation of appropriate heights from parallax measurement; and a few plotting devices were designed to

mechanize the approximate analytic solutions. But the impression of the word 'approximate' and the showers of pamphlets written in praise of the stereoplotting instruments based on the 'exact' geometrical principles kept the attention so fixated on these machines that many photogrammetrists believed that nothing else was worth a place in a modern air survey department.

18. A few years ago the representative of an oil company prospecting in UAR called for advice on the solution of an urgent problem in the western desert. Rather prcise elevations were required, but there was neither the time to determine them in the field nor the inclination to bring in suitable plotting machines. We therefore set to look into the possibility of improving upon the known methods of determining height from parallax measurement. A more rigorous derivation of the functional relationship between height, the parallax and the photographic coordinates led to the development of a simplified method that gave approximately H/6000 for the root mean square error of height determination, H being the flying altitude.

19. To ascertain the theoretical expectations of the method and to clear the ground for further developments the general theory of therepresentation of model deformations by polynomials in the photographic coordinates in any type of terrain was elaborated in a paper published in 1958. The goodness of the representation can be maintained in mountainous regions by means of a simple numerical device. The observational routine is very simple, and the complete set of stereoscope and stereometer is worth qbout £ 80. The calculations need no advanced educational equipment, and the work can be subdivided so that a man can be quickly taught his part. At the same time the method permit of efficient checking and control of production.

20. The utility of the simplified techniques is greatly enhanced by the recent advances in the gyroscopic stabilization of the air camera mounting. Experience in UAR shows that the gyroscopic stabilization keeps the tilts well within one degree. The maximum error due to the replacement of the exact solution of the problem of height determination by the improved approximation to which I alluded is in the order of H/10 000 when each of the tip and the tilt is one degree. This high order of the intrinsic precision makes the 'exactness' of the geometrical solution superfluous but for the most exacting jobs. The additional cost of gyroscopic stabilization is outweighed by the possible simplification of the mapping procedure. The equipment seems, however, to be of a rather delicate balance and needs expert handling. This does not affect its adaptability for use in the developing countries who contract experienced air survey companies to undertake the aerial photography. The proper functioning of all the airborne equipment is in this case the responsibility of the contractors.

21. Good use of the simple methods accomplishes many survey tasks at minimum capital expenditure and evades the difficulties mentioned earlier in this paper. The simple methods help to make a successful start, and give good experience to the young photogrammetrist. At the same time they relieve the stereoplotting machines to the jobs which can not te done otherwise. In the photogrammetric laboratory of the Survey of Egypt we have a team of ob-

servers and computers mapping some 2000 000 feddans for the soil survey project and another team working on the revision of 1/25000 sheets.

PLANNING AND COORDINATION OF SURVEY WORK

22. I shall wind up by submitting a few remarks bearing on the organization of cartographic units and the planning and coordination of survey work:

(a) We have seen that the simple methods of surveying from aerial photographs are most useful when the quality of the photography is best. The combination of good photography and the simple techniques of mapping from it is so potent that the question of securing a reliable source of supply should top all the questions pertaining to the planning of survey work. The recent advances in navigational aids, camera stabilizationm high-resolution distortion-free wide-angle lenses and improved films help to produce the type of photography from which maps can easily be made, and which are most useful for photo interpretation.

(b) Each country will sooner or later find it advisable to have its own survey aircraft. Until then, aerial photography may be entrusted to a reputable air survey company on contract basis. The specifications must be unambiguous and adequate, but the tendency to make them too tight must be checked, first because it puts the prices up and, secondly, because the advisors of the contractors will not fail to find a loophole in a lengthy contract if the rejections are not practically justified. Both parties may be saved unnecessary inconvenience if the contract stipulates the tests and the sampling techniques which will be used to check the quality of the supplied materials.

23. The question of the precision of the maps required for the planning of development schemes needs careful consideration, for there is sometimes a tendency to take for granted the standard of regular mapping, thus making the job costly and time consuming.

24. We recently broke through an interesting example of 'precision barrier'. Our town planners wanted maps at the scale 1/1000 for the larger villages as part of the five-year development scheme. Considerations of time and cost ruled out the use of the standard field methods, and the task would have been impossible to accomplish in time even by photogrammetric methods if the criterion of plottable error were to be upheld at this scale. We therefore made a sample map at the required scale from the photographs previously taken for an experimental crop survey project at the scale 1/10 000. The surrounding fields were plotted from the photographs, and the un-identifiable boundaries were transferred from the available cadastral sheets which were also used to control the scale of the models in the steroplotting machines. The map was carefully examined by the town planners and found to meet their requirements. The project is now advancing satisfactorily at the rate of 17 villages a year per machine working one shift. Each map carries a brief description of the method of production.

25. Where ground control is sparse the slotted template method is still the simplest and most efficient means to control the scale of the models in a block of photographs, particularly if the camera was gyroscopically stabilized. The stereotemplates solve the same problem in mountainous regions.

26. The general problem of height control has no such elegant solution as yet, in spite of the large number of publications on aerial triangulation and block adjustment. Until a revelation of genius solves this problem we have to make the best use of the available ground control to reduce the costly field operations. In certain desert regions of UAR the existing triangulation is dense enough to control the individual models if the photographs are taken from high altitude. Or one occasion we analytically treated the photographs which had been taken from 30 000 feet to obtain control for the lower altitude photography which used for the mapping. The triangulation points were, in the most part, easy to locate on the high altitude photography. To reduce the possibility of errors of point transfer from one picture to the other we observed groups of neighbouring points instead of single points. This also increased the precision. Small-block adjustment solved the problem of height control on another occasion.

27. Modern optical-electronic methods of distance measurement are under experimental studies in UAR to become familiar with their intricacies, and to define their proper scope of application. We also feel that the logistics of field work need revision. Trucks are still used where light aircraft and helicopters would save valuable time.

28. Many years ago the founders of the Survey of Egypt realized that one of the essentials to improvement of the quality of the work was that the computation should be taken out of the hands of the observers and entrusted to a central staff under skilled mathematicians. This rule is observed in most survey establishments, but the responsibilities of the mathematical services have increased by the introduction of modern survey techniques. It would therefore be a miscalculation to start a national survey to-day with no mathematician within call. His duty will include the systematization of the computing. He will fix the standard of precision in the observation and the computation; and will develop and apply a careful system of quality control. Recent researches in the application of mathematical statistics to the analysis of errors in survey work and to the design of experimental studies in this field show that a good background in this subject is a great advantage. It helps us to read the specifications and instrument-performance data more intelligently, to detect flaws due to defective instruments and the indiscretion of an observer or operator; and it teaches us how to design tests and economic experiments to decide the value of suggested improvements.

397 E - Oct.1962 - 1,600

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Agenda Item: A.4.3.1.

United Arab Republi

ELECTRICAL GENERATING PLANTS : UP TO 100 kW

By MOSTAPHA FATHY, B.Sc.

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ELECTRICAL GENERATING PLANTS (UP TO 100 kW)

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Power Generation in U.A.R.

1. In the U.A.R. the task of electrical power generation, transmission and distribution is undertaken by several governmental electricity authorities. These authorities feed all types of loads all over the country, such as municipalities, irrigation and drainage pumping stations, industrial plants, and the large public utility, industrial and traction loads in Cairo and Alexandria.

2. Apart from the above mentioned electricity authorities, there are many industrial companies which generate electrical energy for their own industrial use. Some of these companies combine the production of electrical energy with the economic generation of steam for their own industrial process, such as in the sugar, textile and paper industries.

3. All these electrical energy producers are operating and expanding their systems according to a long range coordinated plan, under the supervision of the U.A.R. Electricity Commission.

4. According to the 1961 statistics, the total installed capacity of these systems is 1308 M.W. and the total energy generated is 3722 million kWh. Although power stations in these systems are not fully interconnected, yet a project is now under adjudication for the construction of 770 kilometers of 220 kV transmission lines and the necessary transformer and switching sub-stations necessary for the complete interconnection of the power stations in Cairo and Alexandria with all other stations in the Delta and Suez.

5. Besides these electrical power systems, there are many small private stationary engines dispersed all over the country. These engines are employed either to drive directly their respective mechanical loads or generate electricity of these engines amounts to more than one million horse-power. The driving engines are either Diesel, semi-diesel, steam, petrol or kerosene engines.

Hydro-electric Plants:

6. The United Arab Republic has got an elaborate system of irrigation depending on several barrages on the Nile as well as numerous regulators on the main and subsidiary canals.

7. Studies for the utilisation of the potential energy prevailing at the main barrages and some of the existing regulators have been made. The conclusion arrived at was that the "Tubular Kaplan turbines coupled to their alternators" were the most suitable and economical units for use on the regulators. The power of these units shall not exceed 100 kW in most cases.

8. In case they could not be installed in the openings on the regulators, they could be installed in simple power houses built on canal diversions. They could also be installed in such a way that they could be easily lifted for repair or for any other purpose and put back in the opening when required. The turbines which are suitable for the main barrages on the Nile have not been mentioned as they are of much higher power than 100 kW.

Thermal Plants:

9. A great number of electric generating plants with internal combustion engines as prime movers were installed in the United Arab Republic in the last few years. The fuel used is petrol, kerosine, solar and Diesel oil. The generators are mostly D.C. The generating sets are used for supplying light or light and power for houses in the country, and light and power for small factories and workshops either in the country or in towns and cities.

10. Difficulties were encountered at the beginning in maintaining Diesel engines owing to the shortage of skilled labour and maintenance workshops. But the difficulties were gradually overcome.

11. The following points are recommended when dealing with less developed countries: -

(a) The altitude and the maximum air temperature when fixing the rated output of the generating sets.

(b) Fitting the engines with renewable liners, so that liners and pistons could be easily changed when necessary.

(c) When compressed air is required for starting the engine, the air bottle should be of sufficient capacity for ten faulty starts at least.

(d) Fitting efficient air filters to the engines.

(e) When Diesel oil is used as fuel, heaters should be installed in the main fuel reservoirs and solar or kerosine service tanks should also be installed for starting purposes.

(f) Supplying an adequate oil purifier for reconditioning the lubricating oil.

(g) Furnishing engines up to 25 B.H.P. with a thermo-syphon cooling systems, and for higher powers with a cooling tower.

(h) Engine makers should supply complete executive drawings and specifications for the engine foundations which should also suit the nature of the soil on site.

(i) Engine makers should supply an instruction book for running, adjusting and carrying out minor and major repairs in the engine.

(j) Maintenance workshops and skilled mechanics should be available.

(k) To offer A.C. three phases 50 cycles alternators is preferable whenever possible when feeding motor powers in order to avoid changing the motors in future if the motors are fed from an electric net system.

(l) It is preferable in hot countries to use class B insulation.

(m) The generators and engines should be erected on one common bed plate.

(n) Spare parts should be made available at a reasonable price.

Non conventional:

12. Some trials were made for generating electricity from sun rays, but the costs were high and the trials were abandoned. Wind mills are used in very small numbers for electric generation as their power besides being very small is not firm.

U.A.R. Electrification Scheme:

13. Cheap energy is generally considered as the basis of sound economical development. Electrification schemes should thus be prepared so as to supply all the consumers,

whether industries, utilities or rural with cheap electrical energy.

14. The plan of the electrification of U.A.R. is based on the study of the future power requirements and the installation of large, high efficiency thermal units to cope with these requirements where fuel and water are economically available. Generation of electrical energy in large central power stations and distributing the energy to the different consumers has proved to be more economical than generating the energy independently for the supply of local needs.

15. The energy generated in central stations is then transmitted through a high voltage transmission - interconnection system, and distributed on all municipal, industrial and rural consumers. The Nile water power will also be fully utilised and the production of the thermal and hydro-electrical energy will be economically coordinated.

16. For the purpose of promoting rural electrification, the five-year plan of electrification comprises the erection and expansion of the medium voltage distribution networks (11kV, 6.6 kV and 3.3 kV) and the low voltage 380/220 volt, local networks of the different municipalities and villages. In arid areas and for villages and towns far from the distribution networks the electrification plan provides for the erection of Diesel - electric statias and the expansion of the existing ones.

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Agenda Item: A.4.3.4

Nigeria

TRAINING CADRES FOR OPERATION AND/MAINTENANCE OF POWER INSTALLATIONS

By E.H. YONREN,
A.M.I.E.E., Asst General Manager
Administration

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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Sub-Item A.4.3.4:

Training Cadres for Operation & Maintenance of Power Installations

E.H.YONREN, A.M.I.E.E., ASST. GENERAL MANAGER (ADMINISTRATION)

1. It is no small problem today having to maintain power installations in a fast developing country like Nigeria. There are clearly three handicaps which must be overcome if continuous supply of power is to be maintained in order to promote industrial growth and expansion. New uses for long service illiterate employees must be found and the efficiency of older employees improved. The best use of unskilled labour must be made and the difficulty of a lack of an industrial or technological background of the effective labour force as a whole must be overcome.

2. There was no formal provision for the instruction and training of new entrants into the electricity industry. An employee was invariably taken on at the bottom of the status scale as general labourer and from then on his vertical progress depended entirely on him. As a general labourer he was attached to an artisan and his job was "fetching, carrying and holding" of tools, gadgets and ladders. The artisan was careful that no one acquired his skill too rapidly or too easily and he was jealous to keep himself in the saddle as boss as long as he could.

3. Those on whom the training of personnel devolved were often men who had started their career in the industry as labourers and who had risen to artisan grades after many years of unorganised training. This does not mean that excellent human material has not been available to the power industry: there are highly skilled men who have run the smaller undertakings with excellent results. Where most of these fail is when a situation arises in which a technical problem is involved. They lack an analytical mind.

4. It is not unusual for linesmen and even technicians to report that the regular fault on a distribution network was due to defective line

materials when the cause may be something else. This is clearly a case of wrong diagnosis. It is quite clear therefore that in the process of developing industries in a young country like Nigeria the unplanned method of training staff for the operation and maintenance of power installations and systems does not meet the needs of the time.

5. There are clearly four classes of workers to be considered - the general labourer, the artisan or craftsman, the supervisor and the technician. In a developing country none of these has any appreciable technical or industrial background and, except for the technician or assistant technical officer, who is better educated, most of the others may have little or no primary school education.

6. The training of the labourer is too often overlooked as being unimportant. This class of worker requires some introduction to the rules and regulations governing the safety of all persons working in the electricity supply industry. It is therefore a useful investment on the part of the employer to give some kind of instruction to labourers.

7. Labourers often think that misplaced enthusiasm which defies safety rules would win the approval of their superiors. It is a good thing therefore to arrange as early as possible after the engagement of a group of labourers a course of instruction on safety. All employees in generating stations or on distribution should be made to attend safety classes.

8. The artisan class is indeed a peculiar class of workers with ideas contrary to known facts and practices in the performance of their duties. This is particularly so on distribution where the linesman is very much exposed to the danger of live overhead conductors. It is not unusual for him to go up a pole and test with his bare fingers if the low voltage line is dead even though he has his test lamp with him!

9. Many artisans exist in the industry who can barely sign their names let alone read and write. Written instructions should therefore be read and interpreted to them several times until these are properly understood. Even with those persons having some primary school education much difficulty is experienced in the understanding of technical instructions. Important directives should be thoroughly explained to all from the grade of artisans mates upwards, and care should be taken to see that all ambiguities are explained because the greatest single cause of inefficiency on the part of these employees is their inability to read and understand instructions.

10. Constant repetition of important instructions is advisable for all staff until a habit has been formed in carrying them out. There are many occasions when there is no point in asking a fitter to carry out a certain operation when he lacks confidence. He will sooner or later acquire confidence and skill in carrying out future assignments of similar nature only when his superior officer takes the trouble to do part of the work with him. The Electricity Corporation of Nigeria realised the importance of training personnel a few years ago and embarked upon the systematic training of power station and distribution staff.

11. Above the artisan is the supervisor who is normally promoted from among deserving artisans and to him is delegated the work of supervising the men on the job. The level of intelligence of the artisan and the supervisor groups has always been about equal and this has resulted in the poor quality of the supervision.

12. A mechanical tradition is only in its infancy in most of Africa and it is not surprising therefore that some of our artisans even after years on the job are occasionally prone to poor performance because of their social and environmental background. To some extent therefore the supervisor has been a glorified artisan whose place is nevertheless important in the electricity supply industry because his status is acquiring some significance as the demand for electricity grows with the development of industries. It is therefore clear that the method of training which requires general labourers to help themselves up the labour scale will not produce the proper men to operate and maintain power installations.

13. The technician grade consists of young men with some secondary school education who have undergone a course of study at a technical institute. Technician training in the past was limited in scope because the field of endeavour was rather small and unambitious. The Public Works Department of the Government was then the only employer and since electricity was at best a rural supply industry it was an insignificant section of that department.

14. The handicaps to the proper development of technical skill were many and included not only the social background of the men as has already been mentioned but also the absence of a national political awareness in pre-independence days. In effect therefore the junior and senior engineering assistants in the past were but glorified fitters, linesmen, and handimen as far as electricity was concerned.

15. The training of older hands is a difficult task bordering at times on the impossible because of their set attitudes to new changes. Refresher courses of a few days or weeks duration are ideal. It is important that all those attending should be aware that they are not attending school as such but are meeting to discuss mutual problems and to investigate new ideas for the furtherance of their efficiency in the industry.

16. The content of such courses should relate to the work the men are already engaged on and the talks should not be of a very high technical nature. These courses must be downright practical and the instructors should use language the men will readily understand. The men should be encouraged to take active part in the discussions which follow and it is advisable to have small discussion groups. Taking part in a general discussion gives them the feeling of "belonging" and of being regarded as responsible grown ups.

17. Refresher courses should provide drawings, sketches and pictures so that important points could be better impressed on the minds of those attending. Films are ideal and should be used if available. It should be remembered that for most of those attending such courses the standard of education will be of the primary education level and care is therefore required in the planning of the talks for discussion. Wherever possible, some practical demonstration should be given by those attending and also by the instructor. A certificate showing that he attended the course should be awarded each participating employee on completing the course.

18. The first realistic move to train staff was launched in 1957 and the first set of men taken on were drawn from the industry, men from power stations and distribution. These men were trained to be supervisors in the Corporation's training school. They were instructed in power station practice, both steam and diesel, and those who later chose distribution as their specialty were taught distribution fundamentals and practice in greater detail.

19. In the training school all the craft apprentices receive a one year basic instruction in general workshop practice - measurements, calculations, drawing, drilling, filing, turning, machining, milling, soldering and brazing and simple fitting. English is also taught. In the second year the boys are divided into two distinct groups - mechanical and electrical - and they continue to receive appropriate instructions. Although specialisation starts in the second year the groups have certain

instructions in common so that, for example, the mechanical fitter is not entirely ignorant of electrical maintenance or the electrical man at a loss in a power station. In the third year the apprentices are sent to a large power station and also to a large undertaking for their practical training.

20. During the third year the mechanical craft boys move from section to section in the power station and this, apart from giving them the requisite practical aspect of their training, also helps them to decide later on what jobs they would like to do. Thus they can choose to be any of the following - plant operator (engine or turbine driver), auxiliary plant attendants, control room operator and maintenance fitter. At the end of the third year the boys should have developed confidence in themselves and be able to tackle any job assigned to them when they are eventually absorbed into the industry. These boys are able to direct subordinate staff and they are resourceful and ambitious.

21. The formal training of craftsmen must be more fully developed. The E.C.N. has found that the boys admitted for training must have a minimum of secondary modern or secondary grammar school (class 4) education but not the General Certificate of Education or the West African School Certificate. During the next two years after their formal training the boys develop more quickly because they realise they have to make their full contribution as craftsmen.

22. For the training of technicians or assistant technical officers, the boys who must have either the West African School Certificate or the General Certificate of Education at ordinary level are sent to the various government sponsored technical institutions where they take sandwich courses in electrical or mechanical engineering leading to the award of the Ordinary Certificate of the City and Guilds and or the approved certificate of the college. The electricals after training are employed on the operation and maintenance of distribution systems while the mechanicals are drafted to power stations where they act as senior operator - supervisors, assistants to shift engineers or maintenance engineers.

23. The Electricity Corporation of Nigeria has plans for expanding its training schemes and looks forward to the time when all its craftsmen will be educated men who have passed through its training school.

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Agenda Item : A. 3. 1. 3

United Arab Republic

THE EVOLUTION OF THE PRINCIPLES AND LAWS ON IRRIGATION AND DRAINAGE IN THE UAR

By Jan NICOLA, B. Sc.,
Ministry of Works, UAR

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THE EVOLUTION OF THE PRINCIPLES AND LAWS OF IRRIGATION AND DRAINAGE IN THE UAR

Jan Nicola, B.Sc.
Ministry of Works, UAR.

PART I

Modification of the Law Relative to Irrigation and Drainage so as to keep Pace with Modern Methods of Water Use.

Introduction -

1. The fact that Egypt's agricultural production depends wholly on the River Nile as a source of water supply has rendered irrigation and drainage problems of paramount importance. It was thus essential to pay careful attention to the effectiveness of irrigation systems on the fertility of the soil and the growing of the different crops. The River Nile together with public canals and drains which are a part of the State Domains form the nucleus of the whole irrigation system in Egypt. For this reason, the administrative legislation, as far as it is concerned with irrigation problems, has given considerable attention to the reorganization of public use of irrigation and drainage methods, with a view to secure public interest and a fair distribution of water.

2. When it was shown by practice that the irrigation and drainage Regulations, in force before 1953, had many gaps to fill in the light of the modern patterns introduced to the irrigation system, the Government passed, in 1953, a comprehensive law reorganizing the use of irrigation and drainage methods. In addition to coded suitable items of the past regulations, the law comprises many chapters dealing with the special conditions necessary for the erection of pumps, irrigation of lands, flood protection measures and other irrigation concerns.

Properties of Individuals in General

3. Thanks to the 1953 laws that all individuals have found easy solutions to their many complicated problems of irrigation and drainage which were to cost them, in the past, a lot of time to get them settled, owing to the long formalities and slack official channels of the old regulations. According to this law, all applications and complaints could now be submitted by individuals, for consideration, directly to the competent Irrigation Services and not through the "Mudir" (Head of the Province' who was not the authority of concern. In this way, much time could be saved and the Administrative Authorities could be freed from many responsibilities which, in fact, ought not to be theirs.

On the other hand, the law has authorized the Irrigation Department to decide, within a certain period, on such applications and petitions reported to the Minister of Public Works. Thus, the slack in procedures, which was before the law, a matter of public complaints, has completely disappeared. Moreover, the law abolished Irrigation Committees and referred their responsibilities, with regard to irrigation and drainage penalties to the ordinary courts. This has greatly helped to secure the rights of individuals. In addition to this, severe penalties were imposed by the law on contravenants of irrigation and drainage principles. Accordingly, selfish and greedy persons who were, under the slight penalties of the past, free to abuse the utilization of irrigation and drainage methods, in a manner harmful to crop production of the adjacent lands and public interest, have now abstained from doing so due to the severe punishment of the law.

Distribution of Water.

4. According to these rules, The Irrigation Department has absolute authority over the distribution of irrigation water to the various kinds of public channels, as well as the distribution of water of every public channel to private intakes feeding therefrom. The Ministry of Public Works fixes the times for the different rotations and dates of winter closure. The Inspector of Irrigation may forbid at any time, even during working stages, the taking of water from a canal or from a series of public canals, in order to guarantee a fair distribution of water or to avoid supplying the lands with extra amounts of water over their requirements.

Flood Risks.

5. The provisions of this part of the law deal with the rules of protection against flood perils and the safety of the Nile banks during flood period. According to the provisions of the previous law, issued in 1899, the guarding and watching of banks were to be carried out freely by the Aid Men. This compulsory service is perfectly organized by the new law to achieve the objectives for which it was issued. Accordingly, all males aged between 18 and 50 years are asked to cooperate in the flood protection against payment to be fixed annually, before the flood occurs, by the Minister of Public Works.

6. In case of abnormal floods, where urgent protective measures are to be taken, the Minister of Public Works may proclaim, by an Arrêté, the state of danger. In this case, those charged to repel the perils of flood must designate the protective works to be executed, and are also authorized to ask the Administrative Authorities to call up the persons needed to help in the execution of such Works.

Public Canals.

7. The irrigation of lands is effected by a network of public canals which derive their waters from the River Nile as well as from main and branch canals maintained by the Government and at its own expenses. Watercourses "Misquas", which carry public canals' irrigation waters to private-owned lands, were, prior to the issuing of the law, considered private, when they serve an

area up to 1000 feddans. Accordingly, such "Misquas" were to be maintained by individuals at their own expense. The law has put an end to the people's troubles by considering such "Misquas" as public canals, regardless of the extension of the area they serve as long as they are directly connected with the Nile or a public canal and derive their waters from either. Consequently, the maintenance of such watercourses is put under the supervision of the Irrigation Department which distributes waters to all beneficiaries fairly.

Public Drains.

8. According to the law, a channel is considered a public drain, when it is intended for drainage and maintained at the expense of the State. They include main and branch drains. Private drains, serving up to 2,000 feddans of individual property lands, are, according to the law, considered a public concern regardless of the area they serve as long as they are directly connected with the Nile, with a public drain or a lake and flow into any of them.

Private Misquas and Drains.

9. Private "Misquas" and drains are the channels which are cleared and maintained, together with their embankments at the expense of beneficiaries. In adapting itself to modern water uses, the law has entitled applicants to promtly construct such private channels within the area of lands belonging to third parties, provided that their construction cost be on the applicants own charge.

Constructional Works.

10. According to the provisions of the law, no private work or alteration whatever is permitted within the area of Public Domains and dealing with irrigation or drainage unless authorized by the Ministry of Public Works in accordance with the terms it puts and after payment of a duty to be fixed by an order from the Minister of Public Works. The Authorized period must not, in any way exceed 10 years. Neverthless, the Ministry of Public Works may, on the date of expiration of such period, deliver a new authorization with the terms it deems necessary. The applicant, to whom the authorization is delivered, must maintain and keep the work in good condition, He is not permitted to carry out any restoration or alteration thereon, unless he is so authorized, in writing, by the Ministry of Public Works. Private bridges that will be constructed across a public canal or drain will be considered, immediately after construction, as part of the public domains which are under the supervision of the Ministry of Public Works.

Intakes of Canals and the delivery of Drains.

11. The construction of water intakes on the banks of the Nile or public canals is not permitted, without previous authorization from the Ministry of Public Works. If the Inspectorate of Irrigation finds out that the discharge of water at intakes, owned by individuals and lying on a bank of a public canal intended for irrigation, raises above or falls below the requirements of the specific land, due to increase or decrease of their number, their

widening, or raise or fall of their bed level, the Government proceeds with the modification of such intakes at its expense. If it is established by the Inspectorate of Irrigation that there exists more than one way for the irrigation of a certain area of land, the Inspectorate may order the suspension of any water intake it considers supplying surplus water to the said area, or to its share of water. This suspension will be at the expense of the Government. Should the Inspector of Irrigation find out during flood period, that a water intake owned by individuals and lying on the bank of either the Nile or a public canal, is endangering such bank, he may then order the owner or those concerned to remove or close it for a convenient time, otherwise the Inspectorate of Irrigation will proceed with such operation at the Government expense.

Water lifting machines.

12. Water lifting machines are of two kinds: hand-operating and mechanical. The installation and the function of hand-operating water lifting machines may be permitted, without authorization, down-stream the openings assigned for irrigation (i.e. in case any deterioration to the lands of others may be encountered). Such hand-operating machines are used for the irrigation of small areas of lands owned by individuals.

13. The erection of mechanical machines is not permitted on public canals and drains unless authorized by the Inspectorate of Irrigation, which indicates in the licence the site of the lifting machine, its type and a brief description, as well as the terms necessary for its installation and operation. Neverthless, in case such an erection is effected on a joint private water-course on drain, the licensee will be solely responsible for such erection, without any liability to the Government. The Irrigation Department has the right, during the authorized period, to stop the pump or apparatus, for a certain period in favour of other beneficiaries, without any right for the person authorized to claim any compensation. The Irrigation Department may cancel any license, should any contravention to its provisions occur.

14. The Ministry of Public Works has reconsidered the question of irrigation rates by lift pumps deriving their waters from either canals or artesian wells. It has thus issued, in 1953, a law fixing irrigation rates to be paid by beneficiaries to owners of such pumps. Ministrial Decrees, fixing irrigation rates (per feddan) of the various sizes of pumps, according to their lift ranges, are issued on account of the water duties of the different zones of the country. Such rents vary according to the prices of fuel.

15. From the preceding paragraphs, it could be concluded that the law has greatly succeeded in ogranizing irrigation and drainage matters. Furthermore, it renders many facilities to the people to obtain their rights and impose upon them the duties which guarantee the use of the best irrigation and drainage methods leading eventually to the development of the national production.

PART II

Law Issued, Providing Field Drainage to Private Domains Its Effect on the Development of Agricultural Production and Raising the Standard of Living.

16. As a matter of fact, a complete drainage system is the keystone of the development of agricultural production. Once a complete drainage system is provided in favourable plant growing conditions, no obstacles whatever could impede agricultural production reaching a climax. It has been observed that although many farmers successfully apply fertilizers and selected seeds, protect their plants against pest diseases and are well to manage good farm patterns, yet the standard of their production is still below that of model fields and farms. This is because they are unable, due to their limited potentialities, to provide their lands with a complete drainage system, which is one of the basic elements which contributes to increasing the agricultural output. In fact, no fruitful results could be obtained from main public and branch drains unless they are connected with networks of field drains, so as to flow off water from every inch of the cultivated stretch. Otherwise, a narrow belt alongside both banks of public and branch drains will be the only area to enjoy full drainage. Neverthless, the decrease of agricultural production in Egypt is mainly due to the farmer's failure in providing their patches with field drains to feed branch and public drains. However, the main reasons for the decrease of agricultural production are briefly as follows:

(a) Farmers' poor knowledge of the benefits of drains.

(b) Increase of a private-owned patches.

(c) Farmers' financial inability to contribute to the preliminary construction costs of field drains, including the price of the expropriated area required for the passage of drains across other private-owned lands.

(d) Desire of minor landlords to keep their own patches undisturbed by the construction of field drains.

17. In 1937, the Government studied every possible means to generalize the use of field drainage in a more easier way, and eventually adopted a new policy. Accordingly, the construction expenses of small drains, serving the numerous private owned lands, was adopted at the Government's expenses. The landlords concerned were made responsible for the maintenance of such branch drains, as well as for the construction of their field drains and connecting them with the former ones, taking into account that priority be given to feeble lands.

18. In 1949, a law was issued authorizing the Government to undertake the projects intended for open field drains and their connection with public drains, provided that the construction cost therein involved be refunded, within a 20-year period, at annual instalments and a 2% interest. In 1956, and 1962 the said law was modified, and the Ministry of Public Works was thus empowered to expropriate and provisionally posses the lands required for the construction of field drains.

19. However, this modification of the law comprises many provisions regarding the construction of covered and open drains. The maintenance of covered drains is put under the Supervision of the Irrigation Inspectorate and executed at the people's expense. The clearance and maintenance of open field drains are carried out by the beneficiaries at their own expense. Should they fail to do so, the Irrigation Inspectorate proceeds with same and recovers the expenses from them administratively. The following are the most important items of this law:

(a) Art. 1. The agricultural land shall be divided for drainage purposes into units. A drainage unit shall be composed of the total lands, the drainage of which is decided to be by a covered or open drain or group of the said drains contributing to a single outlet on the main drain.

(b) Art. 2. The Ministry of Public Works shall expropriate all lands required for the construction of open field drains and cancel all taxes imposed on the lands expropriated for such purposes. It has also the right to expropriate the lands required for the installation of tile field drainage.

(c) Art. The Ministry of Public Works shall proceed with the construction of both kinds of field drains, provided that all lands included within the area of the drainage units must be connected with a chain of the said drains The Ministry shall also proceed, in case of covered field drains, with the construction of minor field branches within the land areas. In both the foregoing cases, the construction costs shall be distributed over the lands situated within the area of the drainage units. This rule is applicable to the construction costs of both kinds of field drains and the minor branches which have been constructed by the Ministry since March, 14th,1949.

(d) Art. 4. Owners of lands situated within the boundaries of a drainage unit and yet unconnected with either kinds of field drains constructed by the Ministry since 1949, shall have the right to demand the construction, in their lands, of junctions to such drains, provided that they must bear the construction costs therein incurred as well as the widening expenses of the existing field drains proportionately.

(e) Art. 5. The Ministry of Public Works shall prepare a comprehensive statement showing all amounts spent on the construction of both kinds of field drains and the lease and expropriation procedures, including compensation due for the expropriated area, cultivations, buildings, trees, machines "Saquias" as well as any other kind of compensation plus 10% against payment of the administrative expenses.

The Ministry shall then indicate the share of each feddan of the area included in the drainage unit.

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Agenda Item : A. 5. 1. 2

United Kingdom

SURVEY AND EVALUATION OF ATOMIC ENERGY RAW MATERIALS

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SURVEY AND EVALUATION OF ATOMIC ENERGY RAW MATERIALS

No. 519

S. H. U. Bowie, Chief Geologist
A.5.I.2 D. Ostle, Principal Geologist

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1. INTRODUCTION

During recent years there has been an unprecedented development in geophysical, geochemical and geobotanical techniques, many of which have been applied in the search for atomic energy raw materials. Indeed, so many methods are available, and so vociferous are their respective advocates, that the non-specialist is often in a quandary in deciding which to employ in a particular region. Experience gained in the past fifteen years has clearly demonstrated to us that a prerequisite of all successful prospecting is basic geological information and a knowledge of the geochemistry of the element being sought. In undertaking the systematic exploration for any type of mineralization, the first essential step, therefore, is to obtain as much geological information on the circumscribed area as is available. From this it is usually possible for an experienced radiogeologist to decide whether the area is geologically, geochemically and structurally favourable for the development of ore bodies. Where geological knowledge is lacking it is often beneficial to obtain preliminary information from the examination of aerial photographs. It is not possible in the space available to list all criteria which may indicate potential areas of mineralization, but some of those having a particular application to the search for uranium and thorium deposits are briefly discussed.

2. TYPES OF DEPOSIT

Uranium and thorium deposits may be classified in a variety of ways. One convenient method based on mode of occurrence is given in Table 1 and may be a useful guide to the selection of localities in which similar deposits may occur. Three generalizations worth bearing in mind in connection with the search for radioactive minerals are:

(a) The major deposits of uranium at present known are located in ancient crystalline rocks or in permeable sediments of younger age, for example, in conglomerates or sandstones.

(b) Uranium minerals are associated regionally with acid rather than basic igneous rocks, although the latter may locally act as favourable hosts.

(c) Thorium minerals occur mainly in placer deposits, which may be recent or fossil, and in veins.

3. GEOLOGICAL GUIDES

Specific geological guides to uranium mineralization vary from province

to province, though some have a wide application in the search for new occurrences. The more important of these are:

(a) Petrogenetic associations. The association of uranium with acid igneous rocks such as granites, granodiorites and rhyolitic lavas has been noted in many parts of the world and it is considered that this results from their common origin. Uranium is frequently found in upper and peripheral portions of granitic intrusions and these should always be examined carefully. Anticlinal and domal uplifts suspected of being associated with such igneous rocks, even though these do not outcrop, are also worthy of attention, particularly the flanks of the uplift.

(b) Structural control. The concentration of uranium, and of other metals, is frequently controlled by structural features in the host rock. The most important of these are tension fractures, intersections of faults, zones of shattering or brecciation, and tight folding in incompetent strata. In relatively flat-lying permeable sediments such as sandstones and conglomerates, concentrations of metals frequently occur where there are sharp changes in texture and composition. One of the best hosts for ore minerals is a coarse-grained sandstone with variations in texture.

(c) Mineral associations. Vein-type deposits of pitchblende and uraninite are commonly associated with copper, lead, zinc, cobalt, nickel and silver ores. Thus all known occurrences of these metals merit examination with modern prospecting instruments. Similarly, any known occurrence of copper, iron, vanadium, selenium or arsenic in sedimentary rocks should be examined as uranium is often found in such an environment.

(d) Chemical affinities. Uranium is frequently enriched by sorption or chemical combination in carbonaceous, phosphatic or ferruginous sediments and although these are not usually as high grade as hydrothermal deposits they may contain vast resources for future use. For example, there are large tonnages of uranium in lignites in North and South Dakota at grades exceptionally as high as 0.2 per cent U_3O_8; marine black shales in Sweden also contain many thousands of tons of uranium at grades of up to 0.03 per cent U_3O_8.

(e) Absolute age of mineralization. The determination by isotopic ratio methods of the absolute age of radioactive mineralization and of the intrusion of acid igneous rocks in areas where primary uranium mineralization is known to occur is of considerable importance. This can give the age of the latest phase of mineralization and so enable younger rocks to be eliminated as likely environments in which to find further uranium. An excellent example of the value of age determination is afforded by work on ore from the Colorado Plateau which showed that the mineralization was much younger than the host rock in which it was generally found. This led to the search being extended from a fairly narrow stratigraphical horizon of Jurassic rocks to rocks older and younger in age and resulted in the discovery of new and important ore fields.

4. METHODS OF PROSPECTING

Once a favourable region has been delineated, a decision has to be taken on which of the many tools at the prospector's disposal should be used in the search. As there is no general guide to this, the various methods are discussed separately and indications given as to where they may best be applied.

(a) Aeroradiometric surveys. One of the most economic, and certainly most thorough, means of covering a large area is by an aeroradiometric survey. Costs per line-mile range from £2.10s. to less than £1, and can be kept to a minimum

by ensuring that radiometric equipment is installed in all aircraft undertaking other investigations on a grid pattern at a suitable flying height. Aero-radiometric surveying can normally be justified only if the geological environment has been shown to be favourable and if the following conditions can be fulfilled:

(i) terrain relief is such that the aircraft can maintain the specified ground clearance with an accuracy of ± 20 per cent.
(ii) the detecting instrument has a sensitivity such that it can be flown at a height of 500 ft. and a spacing of 1000 ft. and detect anomalies with a concentration factor of 10 or less[1].
(iii) climatic conditions are suitable for low level flying.
(iv) terrain covered by dense vegetation, muskeg, desert sand or other superficial deposit is avoided except under special circumstances.
(v) a team of experienced geologists is available to assess anomalies on the ground, as this cannot be done from the aeroradiometric records.

(b) Car-borne surveys. A number of important uranium deposits have been discovered by car-borne radiometric equipment. This method has the advantage of low cost per mile of traverse, but suffers from being limited to areas accessible to vehicles and to the detection of radioactivity in a narrow strip adjacent to the track of the vehicle. The performance of recent equipment has been improved by using a large diameter scintillation crystal as detector and mounting this well above the vehicle to increase coverage.

(c) On-foot surveys. Surveys on foot with Geiger-Müller or scintillation counter should be a routine measure in normal geological mapping or may be used in areas not suited to aeroradiometric or car-borne surveys. There is little to choose between a good G-M counter and a scintillometer, though the latter is generally preferred since it is capable of detecting a low-level anomaly more readily than a G-M counter and can be used at a faster traverse speed. The G-M counter has the advantage of being more easily adaptable for beta-radiation surveys, for the assay of samples in the field and for the survey of shallow boreholes.

(d) Radon sampling. The quantitative determination of the concentration of radon in 'ground air' has been applied successfully in recent years as a method of detecting deposits of uranium obscured by glacial and other superficial deposits. The technique is particularly suited to secondary surveys in an area known to be favourable to uranium mineralization. The apparatus used is a portable alpha-scintillation counter adapted to analyse air extracted from shallow probe holes rapidly and at low cost.

(e) Geochemical techniques. Geochemical techniques have not been widely used in the detection of uranium or thorium because of the relative ease with which the natural radiations from these elements can be detected by the physical methods referred to above. However, a variety of analytical methods have been devised to detect uranium in water samples at levels of down to 0.2 µg/l. A colorimetric method has been developed which enables contents of down to 1.0 µg/l of uranium to be determined at the stream side thus enabling an immediate follow-up of any anomalies to be made. The content of uranium in run-off water is influenced by factors such as pH, degree of dilution, presence of organic matter, bicarbonate ion content, and the solubility of the source mineral, and may be unreliable as a guide to the whereabouts of workable uranium deposits. The technique has its most useful application in country difficult of access - for example in heavily

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[1] Concentration factor = area of anomalous activity in square yards x percentage equivalent U_3O_8.

forested mountain terrain - where it helps to delineate those river basins or tributary valleys in which uranium mineralization is most likely to occur.

(f) Geobotanical methods. Geobotanical methods of sampling and analysing plants in order to detect concentrations of uranium have found a limited application in semi-arid regions where plant roots penetrate to depths of up to 70 feet and may give indications of mineralization not detectable at surface by physical methods.

5. ASSESSMENT OF OCCURRENCES

The evaluation of occurrences of uranium or thorium is undertaken by the techniques normally employed in assessing concentrations of other metallic ores. In addition, however, many of the radiometric methods employed in the search for uranium can be modified to aid in mineral appraisal.

(a) Preliminary examination. The preliminary examination of an area of anomalous radioactivity is normally undertaken by traversing it on a grid pattern with a portable G-M or scintillation counter and preparing an isorad map showing areas of equal radiation intensity. This, together with available information on geology, topography, drainage, secondary mineral development and the equilibrium condition of the ore minerals, helps to locate the mineralization more precisely and indicates the type of occurrence. Subsequent procedure will depend much on experience, but if further work seems justified this will normally involve trenching, sampling and exploration drilling.

(b) Gamma-logging of boreholes. Where core-recovery from diamond-drill holes is poor, gamma-logging equipment may be used to locate and determine the approximate grade of any mineralization. Caution should be exercised in correlating gamma-log readings with grade of ore, since this is only likely to be reliable in particular circumstances and is by no means universally applicable.

(c) Radiometric assaying. At all stages from the location and preliminary examination of an occurrence, a G-M ratemeter with a beta-probe attachment can be used for 'in situ' assaying and for reducing the number of samples requiring chemical analysis. Such equipment may also be used to undertake fairly accurate assays in the field under conditions where the transport of a large number of samples might prove difficult. A beta-probe attachment or small beta-sensitive instrument is also invaluable as a mine-control instrument for delineating material of ore grade.

6. BERYLLIUM DETECTION AND ASSAY

The detection and assay of beryllium ores in the field is facilitated by the use of portable electronic instruments, employing boron trifluoride tubes to measure the neutrons emitted when beryllium is bombarded by the gamma rays from the isotope antimony -124. 'In situ' assays can be made in the field with great rapidity using these instruments, with the result that a high statistical accuracy is achieved. Similar equipment, made for laboratory use, enables accurate assays of beryllium to be made without the need of costly and time-consuming chemical analyses. Indeed, the use of a (γ,n) laboratory instrument can effect an annual saving of as much as £30,000 per equipment as compared with the normal charge made for wet chemical assays. Both field and laboratory instruments are capable of detecting less than 5 ppm BeO.

7. CONCLUSIONS

There is ample scope for new specialized techniques to aid in the discovery and assessment of the raw materials of the atomic energy industry. In

particular, there is a requirement, which may be fulfilled in the near future, for the determination of specific elements in the field. Whatever the role of new specialized techniques, however, there is little doubt that successful prospecting for future supplies of raw materials will depend on a better understanding of the fundamental geological and geochemical processes involved in controlling the deposition of ore minerals in the earth's crust.

Table 1

Classification of Uranium and Thorium Deposits

Type	Primary Minerals	Normal Grade	Examples
Hydrothermal (low to medium temperature)	Pitchblende Coffinite Uraninite	> 0.2% U_3O_8	France; Portugal; Shinkolobwe; N.W. Canada (Great Bear Lake, Lake Athabasca)
Hydrothermal (high temperature)	Davidite	0.1 - 0.2% U_3O_8	Radium Hill, Australia; Mavuzi, Mozambique;
	Monazite	up to 5% ThO_2	Van Rhynsdorp, S. Africa
Pyrometasomatic replacement	Uraninite Allanite	0.04 - 0.1% U_3O_8	Mary Kathleen, Australia
Pegmatite	Uraninite Betafite Euxenite Davidite	Sometimes 0.1 - 0.2% U_3O_8, but not normally workable	Bancroft, Canada; Mozambique; S. Rhodesia; N.S.W., Australia
Disseminated	Uraninite Coffinite Brannerite Pitchblende	0.03 - 0.25% U_3O_8	Witwatersrand; Blind River; Colorado Plateau
Sedimentary phosphates, lignites and shales	No discrete uranium minerals	0.01 - 0.03%; down to 0.006% U_3O_8 as by-product	Florida; N. and S. Dakota; Västergötland, Sweden
Placer	Monazite Thorianite Thorite	> 0.01% ThO_2	Travancore, India; Brazil; Indus R., Pakistan

519 E - Oct. 1962 - 1,600